The Thesis Committee for Erin Poteet
Certifies that this is the approved version of the following thesis:

Equal, Equitable, or Optimal: A comparative analysis of the regional policies and financial structures impacting residential solar adoption

APPROVED BY
SUPERVISING COMMITTEE:

Supervisor:

Fred Beach

John C. Butler

Niraj Desai

Equal, Equitable, or Optimal: A comparative analysis of the regional policies and financial structures impacting residential solar adoption

by

Erin Poteet

Thesis

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degrees of

Master of Science in Energy and Earth Resources

And

Master of Business Administration

The University of Texas at Austin

May 2018

Dedication

To my parents, Larry and Debra, for instilling in me the desire to always improve and nurturing my intellectual curiosity.

To my partner, Niraj, for supporting me through my academic endeavors and encouraging me to pursue my dreams.

Acknowledgements

I would like to thank John A. and Katherine G. Jackson for their generous Energy and Earth Resources fellowship.

I would like to thank Dr. Fred Beach for his support and guidance while pursuing my research, as well as his overall support of the Energy and Earth Resources program. I would also like to thank Dr. John C. Butler and Niraj Desai for their advice and support.

I would like to thank Richard Chuchla and Jessica Smith for their dedication to the Energy and Earth Resources program as well all my fellow EER classmates for their support in pursuing this degree.

Abstract

Equal, Equitable, or Optimal: A comparative analysis of the regional policies and financial structures impacting residential solar adoption

Erin Poteet, MSEER/MBA

The University of Texas at Austin, 2018

Supervisor: Fred Beach

Diversification of energy production is increasingly important as concerns over emissions, energy independence and fuel costs emerge. As such, policies and incentive structures have been put in place by both federal and local government to increase solar energy generation. Since solar energy generation is not confined to utility or commercial scale projects it is feasible for households to become small generators and for local utilities to encourage or discourage residential energy production.

While the cost of solar has been decreasing, installing residential solar PV is still a capital-intensive venture. The impact of residential solar has been debated but the presence of federal tax credits, increasing renewable energy requirements, and reduced emission standards signify that it is a subject cities and utilities must contend with. The Texas cities of Austin, San Antonio, and Georgetown represent three case studies of different programs, policies and financial approaches towards residential solar PV. The findings suggest that most average 20-year residential solar PV projects are net positive for homeowners. 10-year projects in cities that offer up-front rebates, such as Austin and San Antonio, are more

likely to save residents money on the investment over non-rebate cities like Georgetown. 10-year projects without the federal investment tax credit result in mostly net negative financial outcomes for residents.

Each city has utilized a unique a model that can be classified as equal, equitable, or optimal. These models have varying impacts on residents, including consumer reasoning for installing solar and financial feasibility of the investment. Austin and San Antonio have stated goals of increasing renewable energy generation and include residential solar PV in the renewable expansion, because of this, the cities provide more assistance and programs for residents to participate in solar projects. Georgetown already has power purchase agreements in place to fully provide renewable energy to residents and as such are not as interested in incentivizing residential solar PV for the environmental effects.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

Electricity consumption has been steadily increasing over the 20th and 21st century with a recent leveling off; this increase in usage has come with an increase in electricity generation.[1] Traditionally coal has been the main fuel for power plants followed by natural gas as the hydraulic fracturing boom took off in the 2000s. Fears over environmental degradation, increased carbon emissions, a desire for North America energy independence and a diversified fleet of fuels have culminated in a greater push for renewable energy. The US federal government has laid out some basic regulations and requirements, but the onus is on individual states to enact further law in regard to renewable energy production. With the passage of the Public Utilities Regulatory Policies Act (PURPA) in 1978 which allowed for independent energy producers[2] and the Energy Policy Act in 1992 (EPAct92) that eliminated restrictions on competition for wholesale electricity,[3] deregulation of many electric utilities followed. EPAct92 also set a number of laws to increase clean energy use and energy efficiency, notably authorizing tax incentives to encourage commercial sales and production of renewable energy technology. Within each state there are a variety of utilities that function differently from one another and operate based on local agendas. Despite increased federal and state mandates related to renewables, local utilities and governmental agencies have a strong impact on the energy fleet. It is important to explore and compare how cities and their respective utilities approach renewable energy to identify a model that best improves financial outcomes for the city and its citizens while also reducing carbon emissions and securing a diverse fuel fleet for the future.

Chapter 2: Methodology

2.1 Introduction

In order to best compare the approach different cities take towards integrating renewable energy into the local fleet, the test cities must meet a set of criteria. For this comparative analysis, Austin, TX, San Antonio, TX, and Georgetown, TX have been chosen. Each city is in the state of Texas and belongs in the Electric Reliability Council of Texas (ERCOT) interconnection grid, which is an Independent System Operator (ISO) that falls under the purview of the Public Utility Commission (PUC) of Texas.[4] The three cities are located within the same solar resource zone receiving between 5.0 to 5.5 kWh/m2/Day (Figure 1). Texas deregulated the energy markets beginning in 2002 as a way to increase competition and allow for customers to choose a lower cost energy provider[5] but municipally-owned electric utilities ("munis") and electric cooperatives (co-op) can choose whether or not to participate in Texas' retail electric market.[6] The three cities selected are considered "munis" and do not participate in the Texas retail electric market; retail rates are set by community elected city council members or the local governing body.

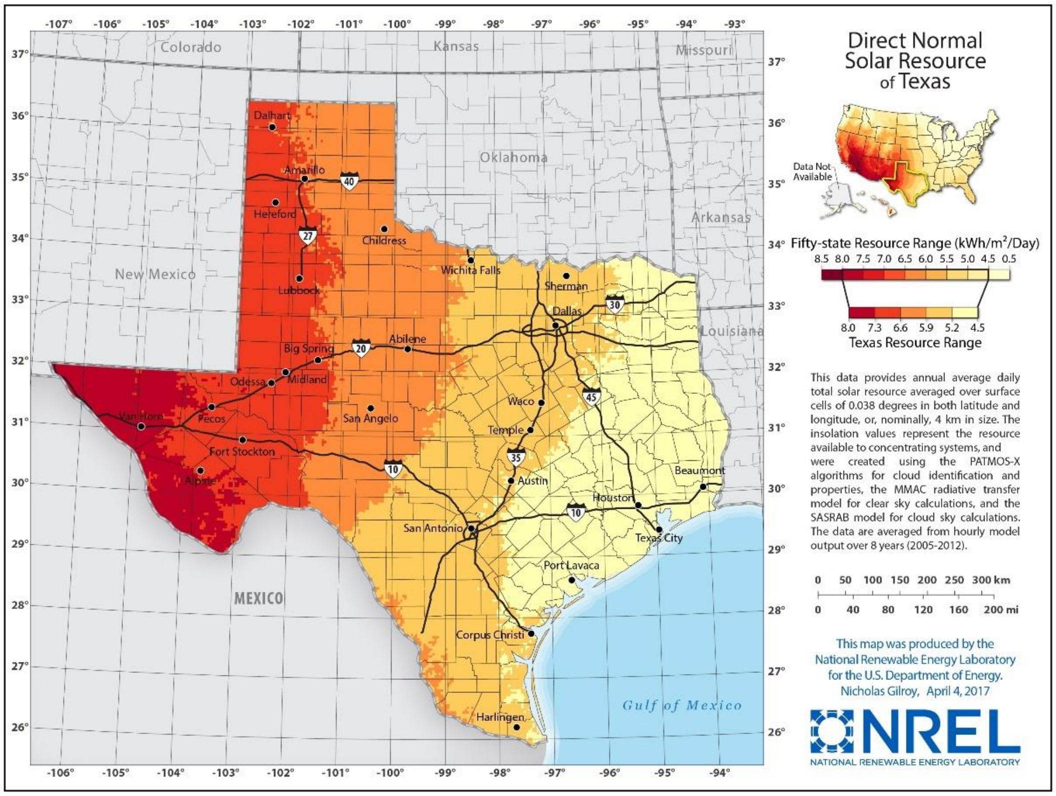

Figure 1: Solar Photovoltaic Resource of the United States.[7]

After constant factors and similarities were established, variables on how each city approached renewable energy, specifically solar and residential solar, were identified. To test the impact of each variable on the cities, a set of metrics was formed which include a cost-benefit analysis for the city and a cost-benefit analysis for the consumer. The cost-benefit analysis for the city includes values associated with federal and state incentives, generation and distribution costs, carbon emission reductions, public perception and optics. The cost-benefit analysis for the consumer includes a multiple scenario approach where identical average households within each city are used to demonstrate the impact of local policies on a consumer's electric bill. A comparison of these metrics was used to identify a financially successful system and a system that best met the priorities of the local utility.

2.2 Utility Analysis Method

To compare each city on a consistent basis, a levelized cost of electricity (LCOE) formula was used for both utility scale solar projects and for residential scale solar projects. The simplified LCOE calculation is essentially the sum of costs over the lifetime of a plant divided by the sum of electrical energy produced over the lifetime, it contains the annual investment expenditures and financing, operations and maintenance expenditures, fuel expenditures, the electricity generated, the discount rate, and the life of the system.[8]

To analyze LCOE, the University of Texas at Austin Energy Institute LCOE side by side calculator was used.[9] The calculator allows for the user to select the county of interest, the fuel source, and the technology. There are additional inputs such as variable costs, capital costs and externalities but selecting the county, fuel source and technology will automatically generate values for these inputs. The generated inputs were used for comparison. The calculator does not look specifically at cities; since the city and utility service area covers most of the county, the county will represent the city and utility for purposes of comparison. Therefore, Travis County was observed as a proxy for Austin, TX, Bexar County for San Antonio, TX, and Williamson County for Georgetown, TX. The fuel source selected for all comparisons was solar. The technology selected for comparison was residential solar photovoltaics and utility solar photovoltaics. The calculator produced a LCOE in $/MWh that can be used to understand the utility cost of electricity in each county for residential and utility solar photovoltaics.

2.3 Residential Analysis Method

For residential solar installation there are multiple financing options that fall under three general categories which are traditional self-financing, third-party ownership and utility and public financing.[10] Under traditional self-financing there is a cash purchase of a residential PV system, home equity loan, home equity line of credit and cash-out mortgage refinancing, for clarity of analysis only the cash purchase self-financing method will be used. Another method of self-financing involves using a loan to finance the PV system and paying off the loan in a pre-agreed time frame with a set interest rate, an interest rate of 5% with a loan term of 15 years was used to aid in comparison. Third-party ownership models, such as the solar lease, were a popular method of financing PV systems but have fallen out of favor with solar installation companies because of low net profit margins[11] and therefore will not be analyzed here.

Under utility and public financing, there a few distinct mechanisms put forth by the utilities being analyzed. One mechanism has the PV system fully funded and maintained by the utility which captures the energy generation and distributes it to the grid and pays the homeowner in the form of a utility bill discount. The credit was incorporated into the model as a reduction to the annual bill and was compared to the electric bills of non-solar PV households and solar PV households. Further explanation and detail of the model can be found in the next section.

2.3.1 Residential Cost-Benefit Analysis

To compare the cost and benefit of installing solar in each city, a base for comparison in the form of an average annual electricity bill needed to be calculated. Texas homes tend to use more energy in the hot summer months than in the winter because of air conditioning so it is inaccurate to use a monthly average kWh usage. The city of Austin open data portal contains monthly average kWh use from 2000 to March 2016 as well as average electricity bills.[12] The weighted average monthly kWh percent, monthly use divided by annual use, was calculated from 2000 to 2015 (Table 1). The data is Austin specific but because of the city's proximity to Georgetown, TX and San Antonio, TX it is unlikely that weather and temperatures differ greatly, therefore the Austin weighted average monthly kWh percent was used for all the cities.

Weighted Average Monthly kWh Percent												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
8%	7%	6%	6%	7%	10%	11%	12%	12%	9%	6%	7%	100%

Table 1: Weighted Average Monthly kWh Usage

Each city has a unique system for calculating the cost of electricity. The weighted average monthly kWh values were applied with respect to each city's billing model to calculate both an average monthly bill and annual bill. This value was projected forward over a period of time and increased annually at a price inflation rate of 2% based on recent US inflation rates,[13] while utility price inflation rates would be more useful, the rates have fluctuated with a current deflationary trend making it a difficult value to use (Figure 2). Georgetown, TX did not include an inflation rate because utility prices will remain constant until 2040 for wind and 2043 for solar due to the 25 year PPA with the EDF Renewable Energy Spinning Spur 3 wind farm and NRG solar farm.[14] In addition to the cost per kWh, the three utilities have a constant monthly customer charge or service availability charge, which are charged regardless the amount of energy used or produced (if the customer has a solar PV system).

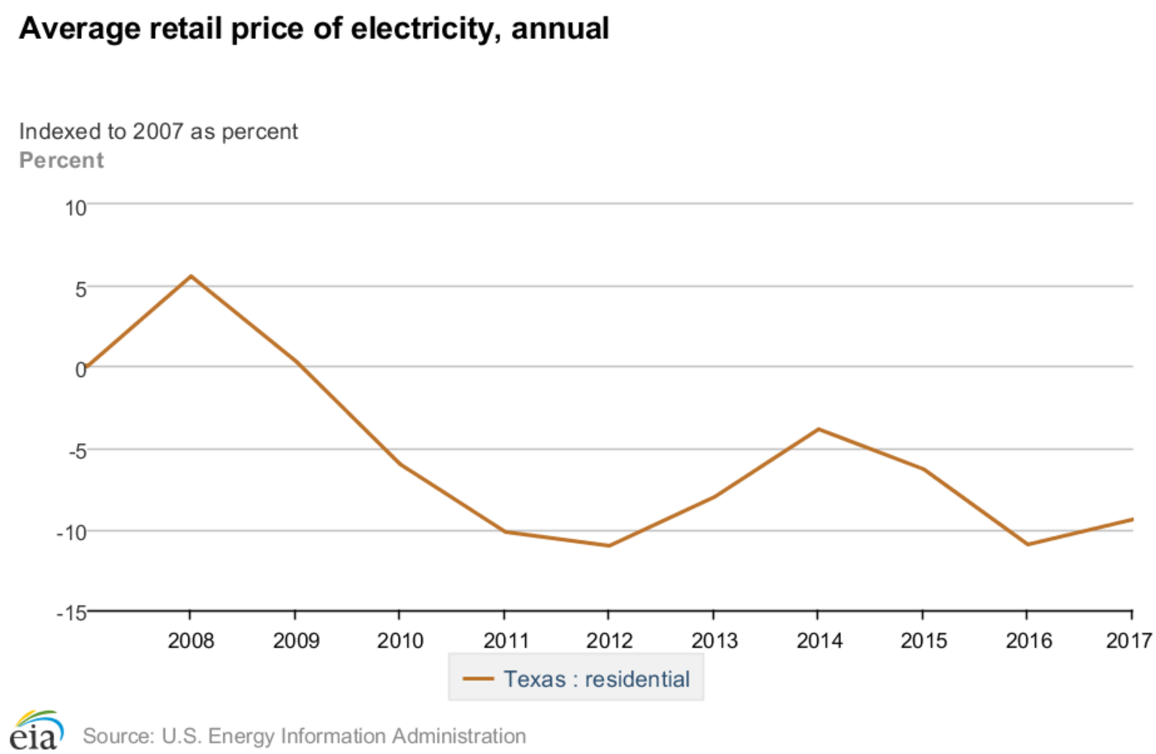

Figure 2: Annual percentage change of the retail price of electricity in Texas.[15]

The cost of PV systems has been declining over time and may differ across regions depending on competition and the availability of installers. For the purposes of this analysis, the average system cost in 2017 for Austin, Texas of $3.22/Watt from the U.S. Department of Energy's Energy Sage site was used.[16] This $/Watt value can be scaled based on the PV system size. The total system cost, $/Watt multiplied by PV system size in Watts, was reduced by the solar investment tax credit (ITC)[17], 1-30%, to calculate the beginning cost of a system for a home in each city. Then individual rebates and solar incentives were applied to calculate the total capital expenditure for a homeowner.

The net present value (NPV) calculation was used to determine what the costs and benefit to a consumer would be in each location using the various financing methods. The savings from producing residential solar were presented as a cash flow that offset the initial capital expenditure of a solar PV system. The PV system warranties typically last 25 to 30 years however a home owner may move before the system warranty expires, the model allows for flexibility in the length one remains in a home. In general, home values in Texas do not increase with the addition of solar panels, so the total remaining cost of the PV system must be paid if the homeowner moves and no additional benefit is added by moving.[18]

The PV panels lose efficiency over time, about 0.50% annual decline in energy output, this decline is called the solar panel degradation rate.[19] The decline rate has been applied to the annual savings on the utility bill from producing solar. To calculate the annual utility bill savings, the difference between annual household energy use and the annual electricity amount produced from the PV system was needed. Household usage is an input, for example 12,000 kWh was used as the base case. The annual production of the PV system was calculated using the NREL formula of kW of PV*(kWh/kW-year)*78%=kWh/year.[20] The kW of PV is an input, for example 7kW was used for the base case analysis, and 78% accounts for the loss due to a DC to AC conversion.[21] To find the kWh/kW-year value, the NREL energy production factor based on geographic location map was used, for the three chosen cities the factor is 1800 (Figure 3). One can then calculate how much of the annual household energy use is replaced by the solar PV system, if the percentage is less than 100% then the value can be multiplied by the annual energy bill cost to find the savings generated by producing one's own power. If the percentage is greater than 100%, then the total cost of the bill is offset and any additional energy generated is sold back to the grid at the net-metered or value of solar price. Therefore, it is possible for the electric bill savings to be greater than an average bill without solar PV. A final factor to consider is the operation and maintenance costs, while this is normally low to nonexistent there may be years when the system needs to be repaired, an assumed value of $50 per year has been added to the model.

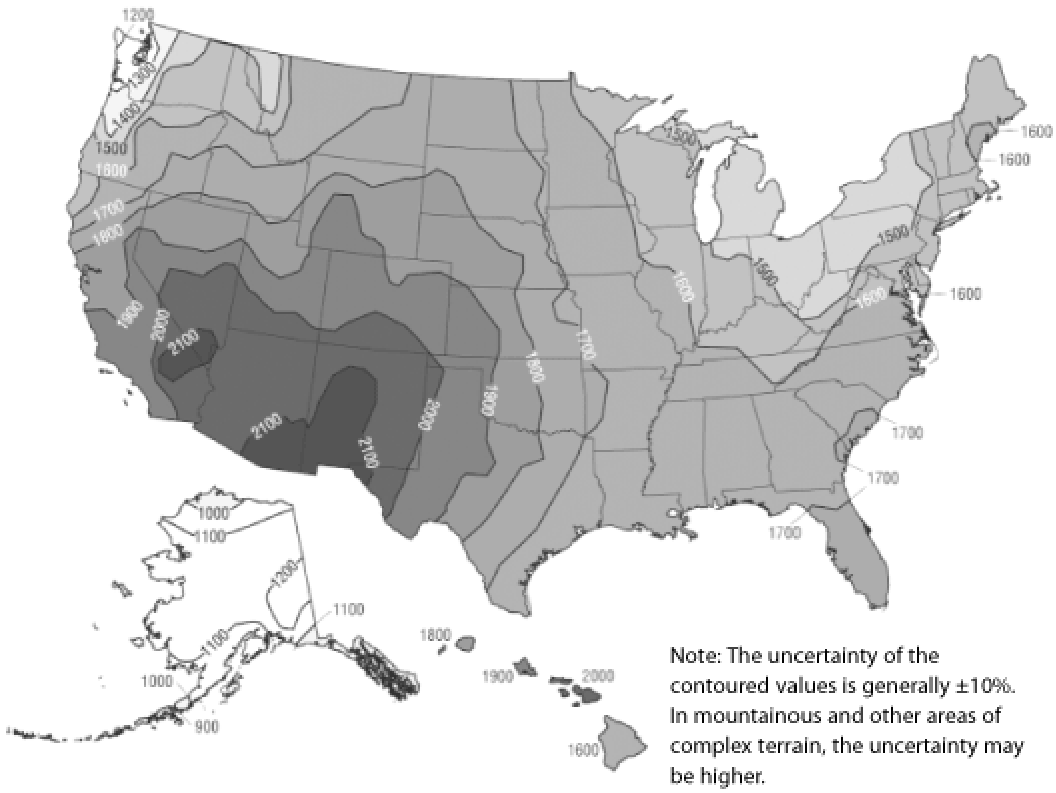

Figure 3: NREL U.S. Energy Production Factors.[22]

These inputs were applied equally to the three cities. To properly evaluate the NPV of an average household installing solar a discount rate representing the cost of capital was needed. A household is not a company so the traditional weighted average cost of capital formula or the capital asset pricing model could not be used. Instead, the interest rate on a Moody's seasoned AAA rated corporate bond yield, 3.55% as of January 2018[23], was used as a proxy for the household discount rate. This rate is representative of a conservative alternative use of capital, investing in a highly rated corporate bond. The difference between the NPV of installing a solar PV system and the NPV of the cost of a traditional energy bill was calculated to find the total cost or benefit of installing solar in Austin, San Antonio, and Georgetown.

Two financing methods were analyzed, a cash purchase of a solar PV system and a loan to finance the system. The loan analysis was based on a 10-year term at an interest rate of 6%. This term and interest rate combination was selected for demonstrative purposes to show the additional amount a homeowner would pay to install solar if they did not have the capital to fund the project entirely. A level payment or mortgage style loan method was used to find the annual payment. For simplicity, it was assumed that the total loan amount would equal the total PV system cost minus the federal and local rebates. This annual loan cost was subtracted from the annual savings from installing solar and an NPV of a system paid for with a loan was then calculated.

A sensitivity analysis was performed to test how each city's rebate and policy structure affected an average customer. Three scenarios were established for household annual electricity usage and for PV system size, the table also portrays the additional variables that were changed including examining the results over a 10-year and 20-year timeline, financing with cash versus loan, and whether or not the federal ITC was included (Table 2). The average PV system size in the US is around 6 kW[24] and the average annual household electricity usage around Austin, Texas is about 12,000 kWh.[25] The medium scenario is most closely representative of Texas averages and is considered the base case while the small and large scenario help to show the range of possible results.

Annual Household Electricity Usage		
Small	Medium	Large
9,000 kWh	12,000 kWh	15,000 kWh
PV System Size		
Small	Medium	Large
5 kW	7kW	10kW
Project Timeline		
10 years	20 Years	
Financing Option		
Cash	Loan	
ITC		
With	Without	

Table 2: Scenario analysis variables.

2.4 Hypothesis

The approach a city takes to implement renewable energy, specifically solar, has a direct impact on the financial outcome of the city and its customers. Cities have different goals that are reflected in their policies, they may aim for a system to be equal, equitable or optimal. The chosen structure and policies that apply to utility scale and residential PV are reflective of the individual cities goal.

2.5 Key Questions to Address

How do local policies and variables within a city impact the cost to a consumer of adopting residential solar? Can a city's goal towards residential solar be defined as equal, equitable, or optimal and what does accomplishing that goal mean for the city and its citizens?

Chapter 3: Texas Renewable Environment

The Texas Public Utilities Commission adopted rules for a renewable electricity mandate in 1999 that required 2,000 megawatts (MW) of renewables to be installed by 2009, a later amendment required 5,880 MW by 2015, and the most recent amendment requires 10,000 by 2025, a goal that has already been achieved.[26,27] Much of the renewable generation has come from wind and as a response the Texas Renewable Portfolio Bill (SB No. 20) set a goal of 500 MW of non-wind generation by 2025.[28] These requirements are applicable to all Texas investor-owned utilities and retail suppliers. An administrative penalty of $50 per MWh renewable generation shortfall exists to penalize noncompliance and incentivize participation in the renewable portfolio standard.[29] Aside from the renewable portfolio standard, Texas does not offer a statewide solar tax or solar rebate program. Local governments and utilities may offer tax incentives, net metering and rebates and therefore it is common to see different incentive structures around renewables from one city to the next. However, nationwide renewable incentives do apply to Texas such as the federal solar investment tax credit (ITC) which offers a 30% tax credit for commercial and residential investors in solar energy property.[30] The ITC is set to step down to 26% in 2020, 22% in 2021, and 0% for residential investors and 10% for commercial and utility investors after 2021. These conditions apply equally to the three cities in this comparative analysis.

Chapter 4: Austin Energy in Austin, TX

4.1 Background

The city of Austin, TX is in Travis County, has a population of 949,587, with a population density of 2,913 people per square mile, and covers a geographic region of 325.94 square miles.[31] The city is served by Austin Energy, a publicly-owned electric utility, which means that Austin City Council serves as the board of directors of the utility. The utility provides energy for 448,000 customers (Figure 4. For Service Area Map) and is fully funded by revenue generated through energy sales and services with $105 million of total revenue transferred to the City of Austin's general fund.[32]

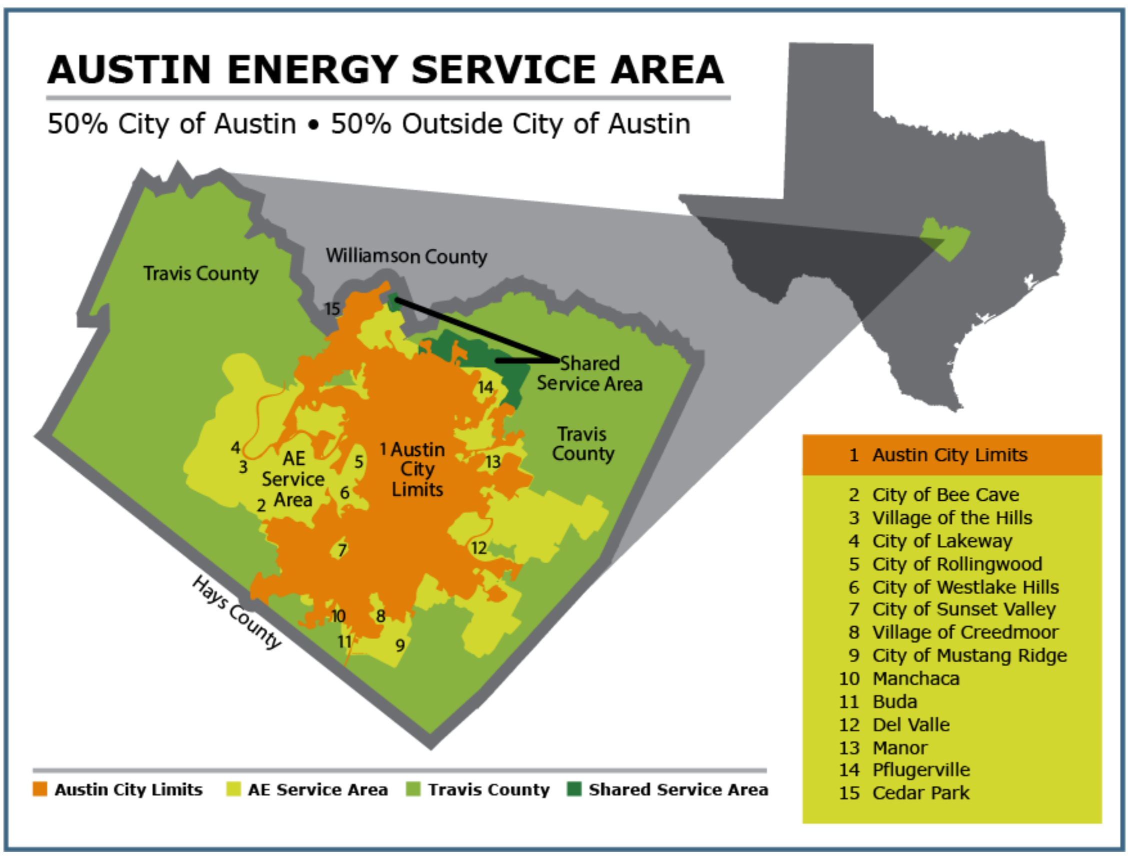

Figure 4: Austin Energy Service Area.[33]

4.2 UTILITY

Historically, Austin Energy has been open to adding renewable power to the fuel portfolio as can be seen by purchasing power from Texas' first commercial wind farm in the 90s.[34] The utility boasts many initiatives aimed at increasing renewable energy generation and decreasing emissions such as the utility's goal of having 55% renewable energy by 2025.[35] Austin Energy's current fuel mix consists of 16.4% from coal, 43.7% from natural gas, 11.5% from nuclear, and 28.5% from renewables which includes hydroelectric, wind, biomass and solar.[36] The utility's total generation capacity is 3,485.3 MW with 30 MW, about 1.0%, coming from the 25-year utility scale Webberville Solar Project power purchase agreement, set to expire in 2036. Austin Energy is making progress to increase solar resources with the recent Roserock Solar power purchase agreement for 157.5 MW of installed capacity set to expire in 2036 and the soon to begin East Pecos Solar (Bootleg) power purchase agreement for 118 MW of installed capacity set to expire in 2031, bringing the total solar generation capacity of Austin Energy to 305.5 MW in 2017.[37]

The utility has set forth a very specific tiered rate system (Figure 5). The intent of the systems is to charge higher energy users more and to incentive the use of less energy.[38] Although rate changes need to be approved by the Austin City Council, rates tend to change on an annual basis. As of November 2017, the Power Supply Adjustment increased by 7.1% and the Regulatory Charge increased by 1.4%, Figure 3 does not reflect the recent Non-Summer Power Supply Adjustment to $0.02936/kWh and summer fee to $0.03007/kWh or the increased Regulatory charge to $0.01362/kWh.

CITY OF AUSTIN UTILITY RATES AND FEES SCHEDULE

For detailed information on rates and fees, call **512-494-9400** or **1-888-340-6465.**

Para información detallada o tarifas en español, llame al **512-494-9400** o llame al **1-888-340-6465.**

J-66113
12/27/16

RATES

Austin Energy — ELECTRIC

Residential Rates

Customer Classification	Customer Charge ($/Month)	Energy Charge ($/kWh) kWh Tier	Power Supply Adjustment ($/kWh) Jun-Sep Oct-May	Regulatory Charge ($/kWh)	Community Benefit Charge ($/kWh)
Inside Residential (Inside City Limits)	$10.00	0-500 $0.02801 501-1000 $0.05832 1001-1500 $0.07814 1501-2500 $0.09314 Additional $0.10814	.02829 .02727 -	$0.01343	$0.00561
Outside Residential (Outside City Limits)	$10.00	0-500 $0.03700 501-1000 $0.05600 Additional $0.07868	.02829 .02727	$0.01343	$0.00369

Figure 5. Austin Energy Utility Rates and Fee Schedule.[39]

4.3 Residential Scale Solar

Within the Austin Energy coverage area, more than 6,250 residential solar energy systems are in place and community solar subscription systems are available.[40] The utility offers two main residential incentives, the first being a rebate on the cost of the PV system and the second being a “Value of Solar” (VOS) credit.[41] The rebate program is designed to compensate participants by paying a predetermined rate per watt up to the smaller of the total system size or 10 kW per home. The program has several incentive levels which are awarded on a first come first serve basis and step down to a reduced incentive amount once the level capacity is reserved or installed. The current program is on level 5, which will pay out $0.40 per Watt and will close once 2,000 kW of capacity are reserved or installed (Figure 6). For a 10kW PV system, the maximum size allowed for a rebate, Austin Energy will reimburse $4,000 towards the cost of the system.

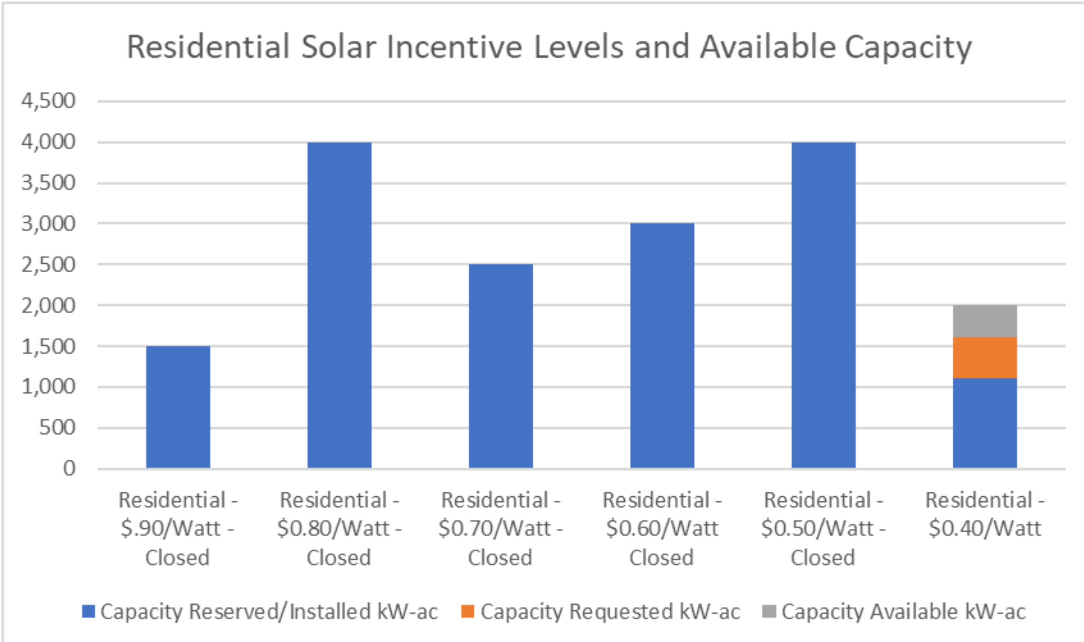

Figure 6. Austin Energy's Incentive Levels.[42]

The VOS credit allows for a homeowner to receive a certain amount of money per each metered kWh output the households PV system produces. The credits are used towards reducing the monthly bill total, not including non-kWh-based charges, and are rolled over if the amount exceeds the bill total. An updated rate schedule became effective November 1, 2017 that allows for a credit of $0.097 for Non-demand output and $0.0670 for Demand output for a system with a less than 1,000 kW-ac output.[43] The VOS credit can lead to a large reduction in a household energy bill if production is high and if household energy usage is low.

Austin Energy provides an additional way for homeowners to participate in residential solar production through its community solar subscription program. Program participants pay a community solar adjustment fee of $0.0427 per kWh instead of the $0.02936 per kWh (winter) and $0.03007 per kWh (summer) power supply adjustment fee to support locally-generated solar energy from the 185-kW solar array at the Palmer Events Center and the 2.6 MW La Loma community solar farm.[44] This program is clearly more expensive than a traditional Austin Energy power bill and will not be analyzed further.

4.4 Financials

The utility's 2016 total revenue was about $1.2 billion, with $.46 billion coming from the residential sector.[45] The average kWh cost for a residential customer is 10.8 cents/kWh. The University of Texas Energy Institute has created an LCOE calculator based on the National Renewable Energy Laboratory's simple LCOE calculator that enables the side by side comparison of LCOE.[46,47] The tool has allowed for a simple comparison of the costs per MWh of utility solar photovoltaics and residential solar photovoltaics with the former being 96.21 $/MWh and the latter being 273.30 $/MWh (Figure 7). While these figures are county based and not focused specifically on the Austin Energy coverage area, it helps to demonstrate the large cost difference between utility and residential solar photovoltaics and aids in explaining why utilities have moved to build up utility scale solar photovoltaics over encouraging residential solar. Despite the price disparity, Austin Energy still promotes and incentivizes residential solar PV installation.

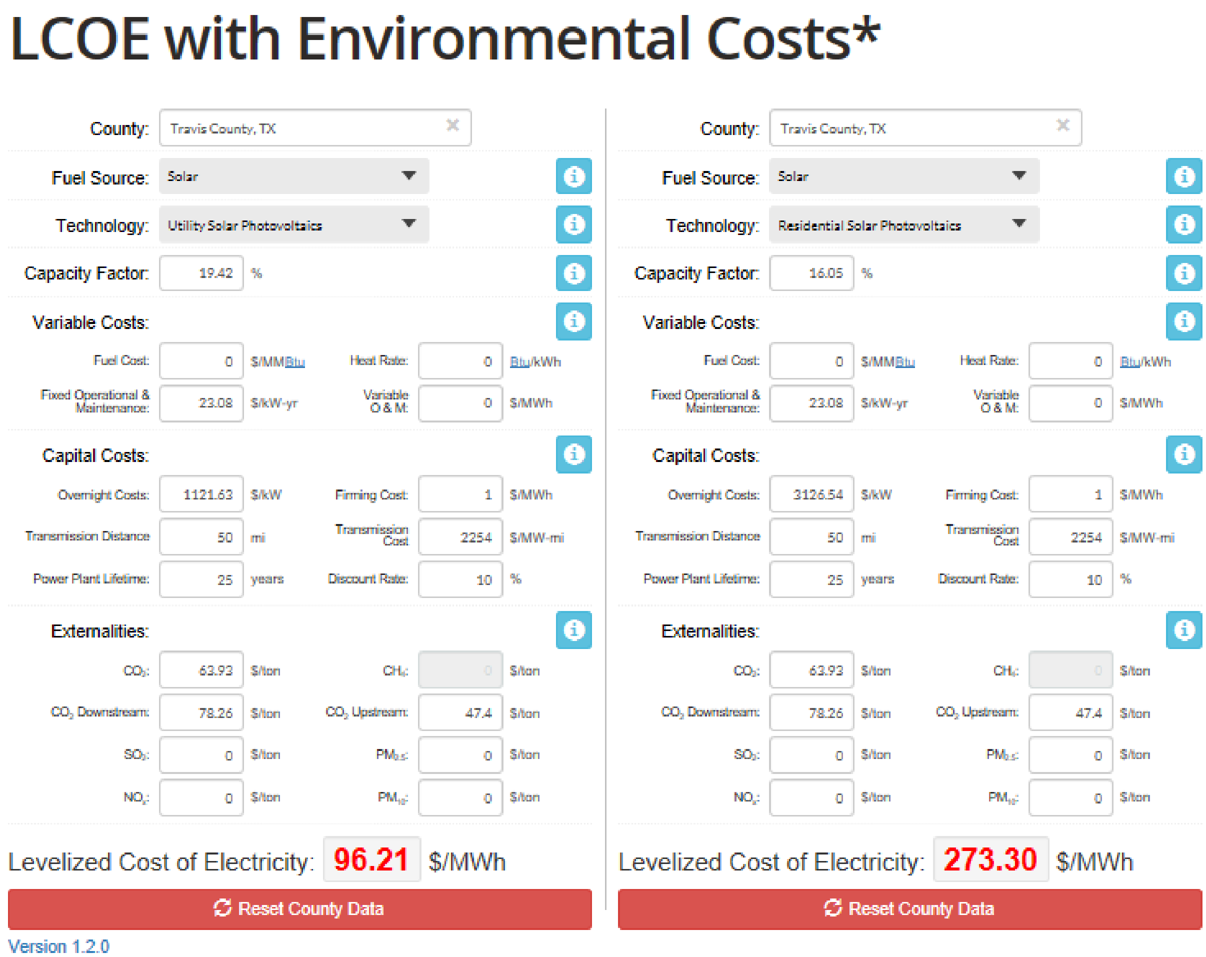

Figure 7. Energy Institute LCOE Calculator: Travis County.

Chapter 5: Georgetown Utility Services in Georgetown, TX

5.1 BACKGROUND

The city of Georgetown, TX is in Williamson County, has a 2016 population of 63,716, with a population density of 1,286 people per square mile, and covers a geographic region of 55 square miles (Figure 8).[48] The city is served by Georgetown Utility Service, a publicly-owned electric utility, which means that Georgetown City Council serves as the board of directors of the utility. The utility provides energy for 45,000 customers and is fully funded by revenue generated through energy sales and services with a percentage of total revenue transferred to the City of Georgetown's general fund.

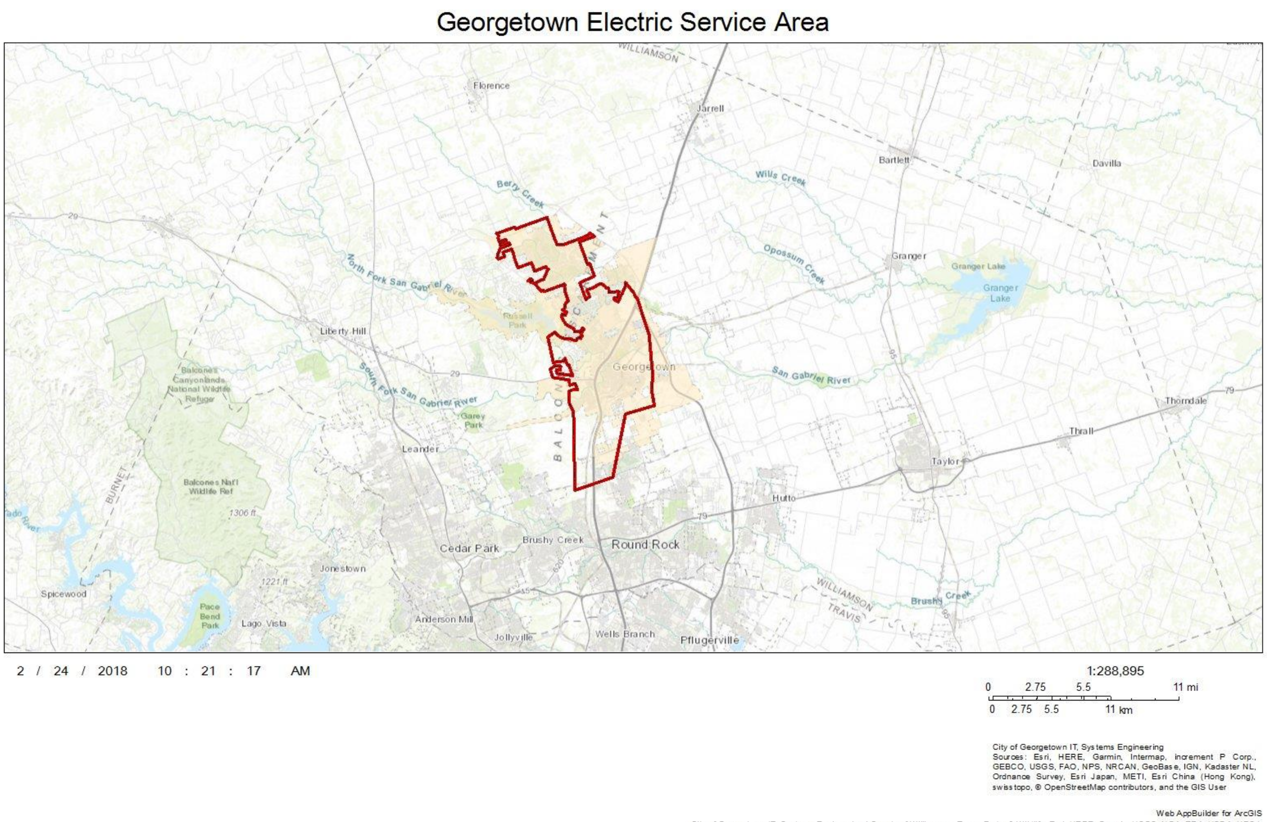

Figure 8: Georgetown Electric Service Area (red outline).[49]

5.2 Utility

The city historically received power through a long-term contract with LCRA that began in 1940 and was supposed to end in 2016. The LCRA contract ended abruptly in September 2012 leaving the city of Georgetown with no power contracts. If the LCRA contract had continued, the city would have received energy from coal powered plants with some from natural gas. Instead, the city had to solicit for new energy providers with the lowest cost, flat rate, bid coming from the Spinning Spur 3 wind farm. The city finalized a contract with the wind farm in December 2013 and the wind farm began operating in September 2015. A second round of bidding produced a natural gas and solar option that were of the same value, the solar option was chosen because the developer agreed to hold a flat rate for 25 years. The two power purchase agreements with the EDF Renewable Spinning Spur 3 wind farm and NRG solar farm, provide enough energy to power Georgetown on 100% renewable energy. The city will be 100% renewable on July 1, 2018, when the NRG utility scale solar farm is complete. The project will deliver 150MWs ac of power at a flat rate until 2043.[50]

The Georgetown utility does not have a complicated tiered rate system. Customers are charged a flat customer charge per month plus the sum of energy charge, power cost adjustment and transmission cost of service multiplied by total household usage in kWh. The customer charge is $20 per month, energy charge ins $0.0939/kWh, power cost adjustment is $0.004/kWh, and the transmission cost of service is $0.0019/kWh. Because of the long-term power purchase agreement to provide power at a fixed rate it is unlikely that utility prices for residents will increase.

5.3 Residential Scale Solar

The city and utility provides some resources to aid customers in the decision to purchase solar photovoltaic by offering a website with a step by step process on how to obtain solar, including details on the required permits.[51] The city does not offer any tax incentives, access to specific solar photovoltaic loans, or installation rebates. Georgetown does net meter at the full retail rate, meaning that excess energy generated by a residential system is bought back by Georgetown electric at the full rate.

5.4 Financials

The utility generated a 2016 revenue of $65,174,374 with a final total fund balance of $6,436,145.[52] The average kWh cost for a customer is 9.39 cents/kWh.[53] The LCOE calculator tool has allowed for a simple comparison of the costs per MWh of utility solar photovoltaics and residential solar photovoltaics with the former being 95.72 $/MWh and the latter being 271.93 $/MWh (Figure 9). While these figures are based on Williamson County and not focused specifically on the Georgetown Utility Services coverage area, it helps to demonstrate the large cost difference between utility and residential solar photovoltaics.

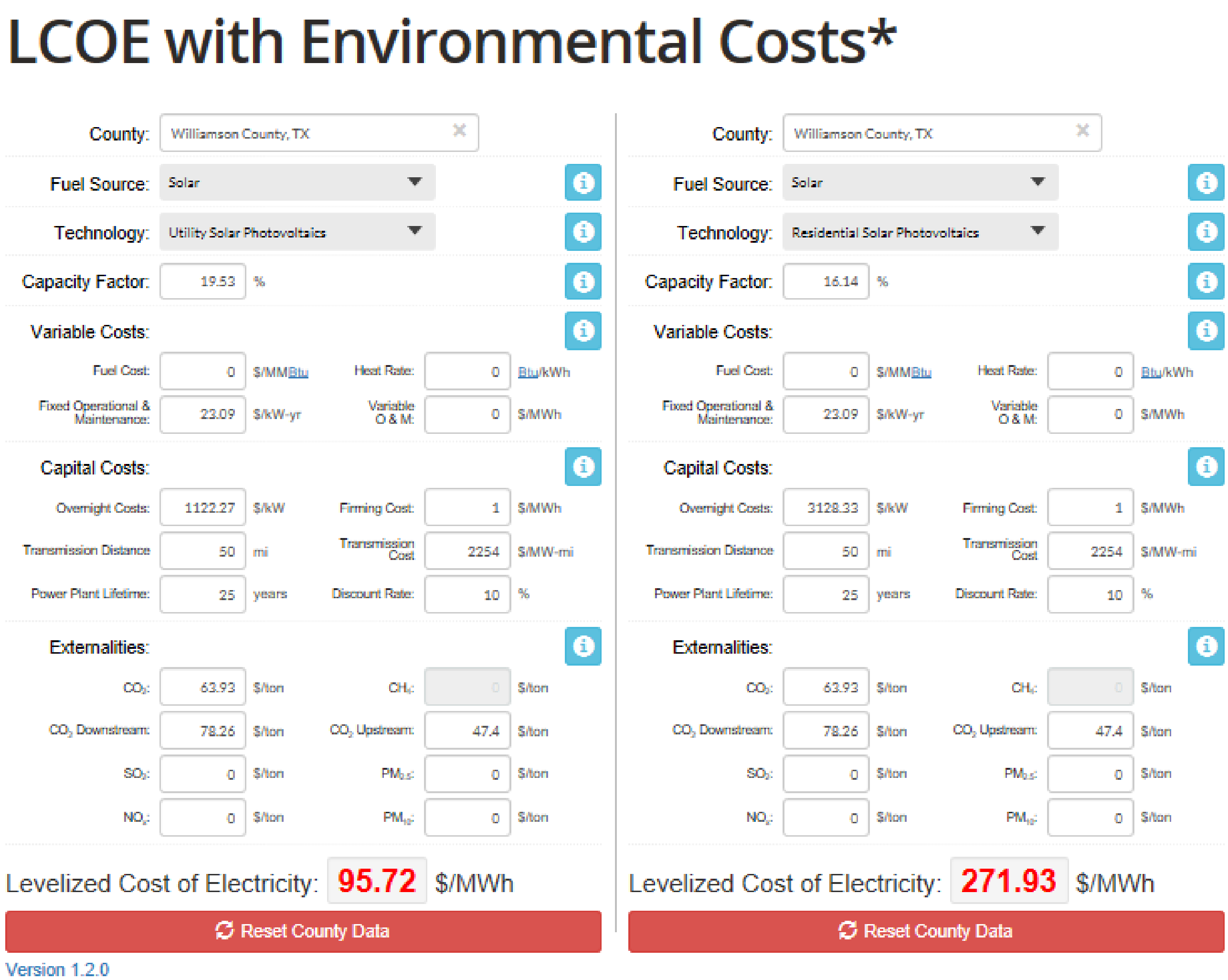

Figure 9. Energy Institute LCOE Calculator: Williamson County.

Chapter 6: CPS Energy in San Antonio, TX

6.1 BACKGROUND

The city of San Antonio, TX is in Bexar County, has a population of 1,492,510, with a population density of 3,000 people per square mile, and covers a geographic region of 490 square miles (Figure 10).[54] The city is served by CPS, a publicly-owned electric utility, which means that San Antonio City Council serves as the board of directors of the utility. The utility provides energy for 804,000 customers and is fully funded by revenue generated through energy sales and services with a percentage of total revenue transferred to the City of San Antonio's general fund.[55]

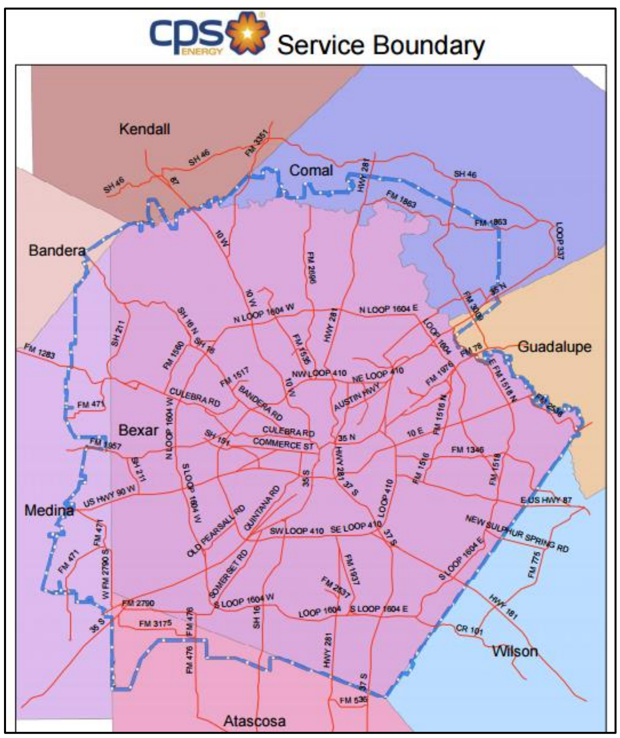

Figure 10: CPS Energy Service Territory.[56]

6.2 Utility

CPS, which stands for City Public Services, was acquired by the city of San Antonio in 1942. The utility has a generation capacity of over 7500 MW with 15 gas units generating about 3,300 MW of energy, a 40% stake in the South Texas Project generating 1,088 MW of nuclear power,[57] ownership in four coal units that produce over 2,000 megawatts of power,[58] 1,060 MW of wind-generated energy through a power purchase agreement, and about 10 MW from landfill gas.[59] The utility had a stated goal of having 20%, or 1,500 MW, of total generation capacity from renewable energy by 2020.[60] That goal has been achieved with 22% of CPS Energy's generation coming from renewable sources and a new goal of nearly half of generation coming from renewable sources by 2040.[61] CPS has 500 MW of solar power, which includes utility-scale and residential-scale solar, and an additional 50 MW planned for 2018.[62]

The utility bills customers with a two-tiered schedule where customers are charged a flat service availability fee, an energy charge, a peak capacity charge, a fuel adjustment charge and a regulatory charge. The service availability charge of $8.75 is charged regardless of solar production or energy use. The energy charge of $0.0691/kWh, the fuel adjustment charge of $0.01525/kWh, and the regulatory adjustment charge of $0.01007 are applied to all kWh of energy used. The peak capacity charge of $0.0198 is applied to all kWh used about 600kWh per month.[63]

6.3 Residential Scale Solar

CPS Energy offers several programs focused on residential solar photovoltaics. The utility offers rebates for residents that install rooftop solar. The rebate is funded by a $10 million fund that has been divided into three tranches based on a first come first serve model, the first being $1.20 per watt, the second being $1.00 per watt and the third being $0.80 per watt, with rebates listed at the third tranche until funds run out.[64] As of April 19, 2017 an additional $15 million has been allocated by CPS Energy to fund solar rebates with $9 million of that dedicated to residential projects. The latest rebate is $0.70/AC watt if the system is manufactured locally and includes a $0.60/AC watt base incentive, and $0.08/AC Watt and $0.02/AC Watt premium for modules and inverters manufactured locally, respectively. The rebate cannot exceed $25,000 for residential projects and if components are not produced locally the rebate amount will be reduced by 25%.[65] CPS energy provides additional programs under the title Simply Solar, these programs include the SolarHostSA and the Roofless Solar program. The Roofless Solar program allows participants to purchase a share in a community solar farm and then receive an energy bill reduction in the form of a credit for the energy that their share produces.[66] This provides an option for residents that are unable to install solar. The program is currently at capacity and not accepting new participants.[67]

6.3.1 SolarHostSA

The SolarHostSA program is where the utility essentially rents the roof of the customer, installs a full system and collects and redistributes energy collected back onto the grid. The household then receives a $0.03 kWh reduction to their monthly electric bill. The solar panel system is installed and maintained by PowerFin; after 20 years the company and CPS Energy will remove the equipment and restore the roof to its original condition. If the home is sold, the credit and arrangement is transferred to the new homeowner. The program is free to participants and qualifying participants can expect to have their home evaluated and the system installed in a total of 8-12 weeks.[68] The program is beneficial for CPS Energy because of the guaranteed $0.03/kWh for 20 years from all participants in the program and the ability to increase renewable energy production to meet the city’s renewable portfolio goal.

6.4 FINANCIALS

The utility generates a 2015 revenue of about $2.7 billion with $2.4 billion coming from electric sales. The average kWh cost for a customer is 10.75 cents/kWh.[69] The LCOE calculator tool has allowed for a simple comparison of the costs per MWh of utility solar photovoltaics and residential solar photovoltaics with the former being 97.21 $/MWh and the latter being 275.99 $/MWh (Figure 11). While these figures are county based and not focused specifically on the CPS coverage area, it helps to demonstrate the large cost difference between utility and residential solar photovoltaics and aids in explaining why utilities have moved to build up utility scale solar photovoltaics over encouraging residential solar.

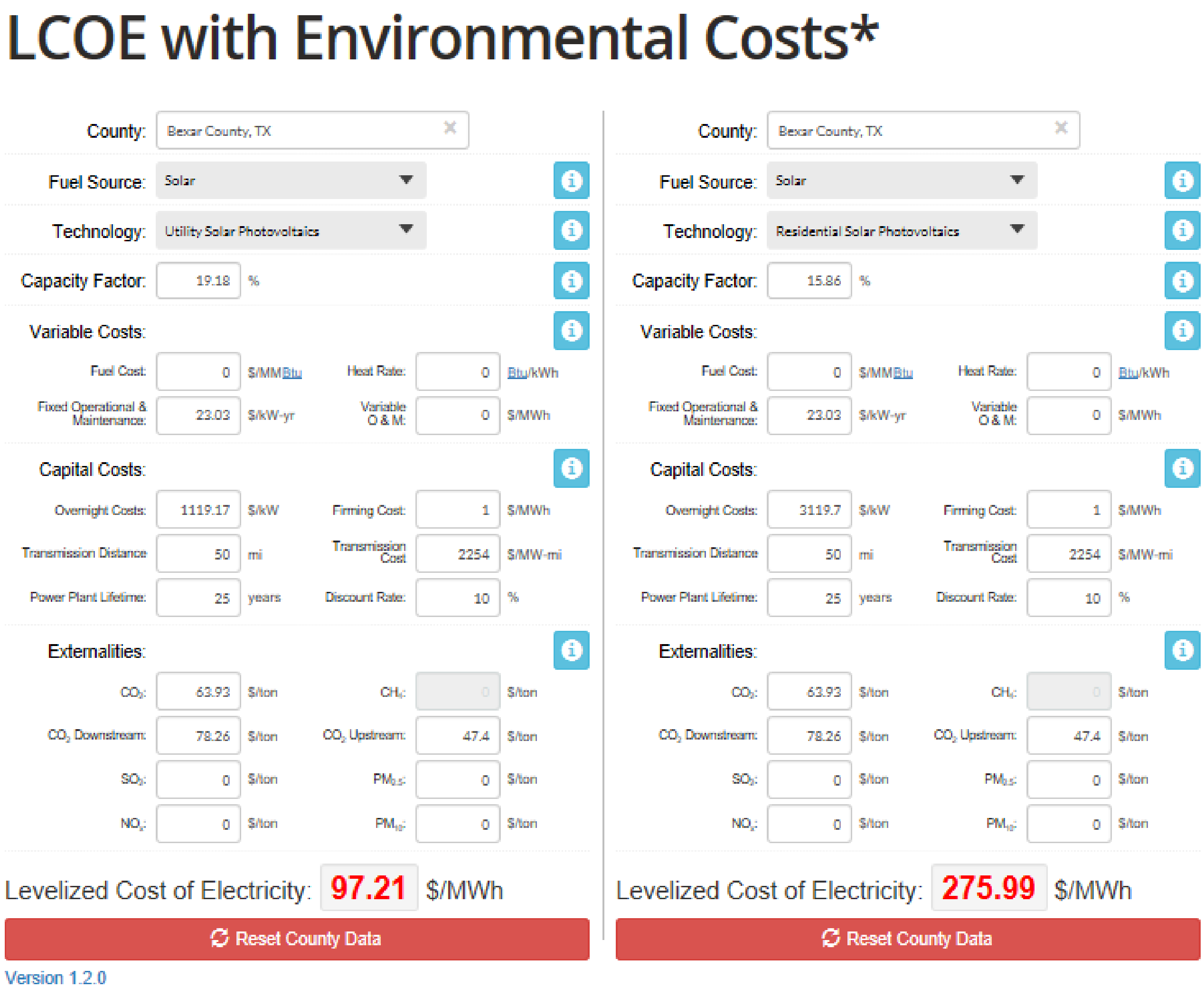

Figure 11. Energy Institute LCOE Calculator: Bexar County.

Chapter 7: Results

7.1 Austin Energy

The base case scenario used for Austin, Georgetown, and San Antonio was a system size of 7kw and 12,000 kWh average annual energy use. A range of cases were evaluated to observe the delta between an average energy bill with and without residential solar PV. Figure 12 depicts what the monthly and annual energy bill for a home that uses 12,000 kWh per year in the Austin Energy territory. The calculated average is $0.105/kWh which is close to the Austin service area average of $0.1066/kWh (Table 3). The annual bill was used in the DCF analysis as well as for the delta calculation for the cash and loan payment method (Figure 13).

The results for the three scenarios under different constraints in Austin can be seen in Table 4. The 20-year timeline cash and loan payment methods have a positive delta under each scenario. Which means that a homeowner that pays cash for a 5-10kWh system and uses between 9,000-15,000 kWh per year can expect to save a minimum of $12,594 and up to $24,702 over a traditional electric bill. While not as high, the results for a 10-year project timeline is mostly positive, the exception being the 10kWh system with an annual usage of 9,000 kWh, indicating that installing solar is still financially beneficial over a shorter time horizon. However, the Austin homeowner could simply increase energy efficiency and reduce energy usage by 3,000 kWh annually and save $0.105/kWh*3,000kWh=$315 per year, or $3,150 (not discounted) over 10 years. This potential savings through energy efficiency indicate that some of the scenarios are less favorable and it is important for a homeowner to evaluate all possible means of reducing energy usage before installing residential solar PV.

The ITC is set to step down in 2019 and cease in 2021 so it is important to test how local incentives affect residential solar PV without the government tax credit. The 20-year project without the tax credit is positive with a minimum savings of $3,265 and a maximum savings of $20,037. The savings are much lower than with the ITC but show that it is still financially beneficial for homeowners to install solar if they plan to stay in the home for 20 years. The results for the 10-year project timeline are starkly different than the previous scenarios with most of the outcomes being negative except for the 5kWh system for a home of 12,000 and 15,000 annual kWh usage and the 7kWh system for an annual usage of 15,000 kWh. Much of the meager savings could be realized by reduction of annual energy use. This indicates that without the ITC a large system size is financially costly to a homeowner that plans to sell their home after 10 years.

2016 Utility Bundled Retail Sales- Residential

(Data from forms EIA-861- schedules 4A & 4D and EIA-861S)

Entity	State	Ownership	Customers (Count)	Sales (Megawatt hours)	Revenues (Thousands Dollars)	Average Price (cents/kWh)
Austin Energy	TX	Municipal	414,091	4,278,102	456,157.3	10.66
City of Georgetown - (TX)	TX	Municipal	22,212	251,920	29,029.4	11.52
City of San Antonio - (TX)	TX	Municipal	709,943	9,494,357	1,018,456.0	10.73

Table 3: Average price per kWh.[70]

Austin Energy Tiered Rates

Inside City Limits		
Customer Charge	10	$/month
0-500 kWh Tier	0.02801	$/kWh
501-1000 kWh Tier 2	0.05832	$/kWh
1001-1500 kWh Tier 3	0.07814	$/kWh
1501-2500 kWh Tier 4	0.09314	$/kWh
Additional	0.10814	$/kWh
Power Supply Adjustment		
Jun-Sep	0.02936	$/kWh
Oct-May	0.03007	$/kWh
Regulatory Charge	0.01362	$/kWh
Community Charge	0.00561	$/kWh
Sales Tax	1.00%	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Monthly	937	808	749	711	830	1157	1374	1438	1407	1036	765	788	12000
Tier 1	14	14	14	14	14	14	14	14	14	14	14	14	168
Tier 2	25	18	14	12	19	29	29	29	29	29	15	17	267
Tier 3	0	0	0	0	0	12	29	34	32	3	0	0	110
Tier 4	0	0	0	0	0	0	0	0	0	0	0	0	0
Additional	0	0	0	0	0	0	0	0	0	0	0	0	0
Cost before Service Charge	86	72	66	62	75	112	140	148	144	97	67	70	1139
Total Cost	$ 96	$ 82	$76	$72	$85	$122	$150	$158	$154	$107	$77	$80	$1,259

Average $/kWh	$	0.105
Annual Bill	$	1,259
Bill without customer fee	$	1,139
Required Minimum		120

Figure 12. Austin Energy Estimated Bill for 12,000 kWh Energy Use.

Austin Energy

Inputs		
Value of Solar Tariff VOST	0.097	$/kWh
Inflation Rate	2.0%	
Residential PV Rebate	0.4	$/Watt
Rebate Max Capacity	10	kW
Rebate Max	4,000	$/System
O&M Costs	50	
Life of System	20	

Discounted Cash Flow	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Total PV System Cost	(22,540)																				
Rebate	2,800																				
Federal Tax Credit	6,762																				
Net Cost of PV System	(12,978)																				
O&M Cost		(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)
Electric Bill without Solar		1,139	1,161	1,185	1,208	1,232	1,257	1,282	1,308	1,334	1,361	1,388	1,416	1,444	1,473	1,502	1,532	1,563	1,594	1,626	1,659
Solar Panel Degradation		-	0.50%	1.00%	1.50%	2.00%	2.50%	3.00%	3.50%	4.00%	4.50%	5.00%	5.50%	6.00%	6.50%	7.00%	7.50%	8.00%	8.50%	9.00%	9.50%
Value of Solar Tariff Credit		953	949	944	939	934	929	925	920	915	910	906	901	896	891	887	882	877	872	868	863
Electric Bill Minimum		(120)	(122)	(125)	(127)	(130)	(132)	(135)	(138)	(141)	(143)	(146)	(149)	(152)	(155)	(158)	(162)	(165)	(168)	(171)	(175)
Cash Flow	(12,978)	783	776	769	762	754	747	740	732	725	717	709	702	694	686	678	670	662	654	646	638
Cumulative Cash Flow	(12,978)	(12,195)	(11,419)	(10,650)	(9,888)	(9,134)	(8,387)	(7,647)	(6,915)	(6,190)	(5,473)	(4,764)	(4,062)	(3,368)	(2,682)	(2,004)	(1,334)	(671)	(17)	629	1,267
NPV	(2,681)																				
Simple Payback Period	19.03																				
IRR	0.94%																				

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Electric Bill Without Solar		(1,259)	(1,284)	(1,309)	(1,336)	(1,362)	(1,390)	(1,417)	(1,446)	(1,475)	(1,504)	(1,534)	(1,565)	(1,596)	(1,628)	(1,661)	(1,694)	(1,728)	(1,762)	(1,798)	(1,833)
NPV of Electric Bill	(21,143)																				

Delta Electric Bill Savings	18,461

With Loan	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Loan Amount	(12,978)																				
Electric Bill Savings		953	949	944	939	934	929	925	920	915	910	906	901	896	891	887	882	877	872	868	863
Electric Bill Minimum		(120)	(122)	(125)	(127)	(130)	(132)	(135)	(138)	(141)	(143)	(146)	(149)	(152)	(155)	(158)	(162)	(165)	(168)	(171)	(175)
Interest Expense		(1,729)	(1,729)	(1,729)	(1,729)	(1,729)	(1,729)	(1,729)	(1,729)	(1,729)	(1,729)										
Annual Cash Flows		(896)	(903)	(910)	(917)	(925)	(932)	(939)	(947)	(954)	(962)	759	752	744	736	728	720	712	704	696	688
NPV	(3,434)																				

Delta with Loan	17,708

Figure 13: DCF and delta of savings of 7 kWh residential solar PV project in Austin, TX.

Austin, Texas									
20 Years with ITC									
Cash	PV System Size in kW				Loan	PV System Size in kW			
Annual kWh Use		5	7	10	Annual kWh Use		5	7	10
	9,000	$12,631	$12,616	$12,594		9,000	$12,268	$11,863	$ 11,255
	12,000	$18,476	$18,461	$18,439		12,000	$18,114	$17,708	$ 17,101
	15,000	$24,702	$24,687	$24,665		15,000	$24,339	$23,934	$ 23,326
10 Years with ITC									
Cash	PV System Size in kW				Loan	PV System Size in kW			
Annual kWh Use		5	7	10	Annual kWh Use		5	7	10
	9,000	$ 3,165	$ 1,720	$ (447)		9,000	$ 2,425	$ 539	$ (2,290)
	12,000	$ 6,308	$ 4,863	$ 2,696		12,000	$ 5,568	$ 3,682	$ 853
	15,000	$ 9,655	$ 8,210	$ 6,043		15,000	$ 8,915	$ 7,029	$ 4,200
20 Years without ITC									
Cash	PV System Size in kW				Loan	PV System Size in kW			
Annual kWh Use		5	7	10	Annual kWh Use		5	7	10
	9,000	$ 7,966	$ 6,086	$ 3,265		9,000	$ 6,930	$ 4,390	$ 579
	12,000	$13,812	$11,931	$ 9,111		12,000	$12,776	$10,235	$ 6,424
	15,000	$20,037	$18,157	$15,336		15,000	$19,001	$16,461	$ 12,650
10 Years without ITC									
Cash	PV System Size in kW				Loan	PV System Size in kW			
Annual kWh Use		5	7	10	Annual kWh Use		5	7	10
	9,000	$ (1,499)	$ (4,810)	$ (9,775)		9,000	$ (2,913)	$ (6,934)	$(12,966)
	12,000	$ 1,644	$ (1,667)	$ (6,633)		12,000	$ 230	$ (3,791)	$ (9,823)
	15,000	$ 4,991	$ 1,680	$ (3,286)		15,000	$ 3,577	$ (444)	$ (6,476)

Table 4: Scenario results under 4 different constraints indicating the cost savings (losses) of installing residential solar PV over paying traditional energy bill in Austin, TX.

7.2 Georgetown Utility Service

The monthly and annual energy bill for a home that uses 12,000 kWh per year in the Georgetown Utility service area is depicted in Figure 14. The calculated average is \$0.122/kWh which is a bit higher than the Georgetown service area average of \$0.1152/kWh (Table 3). The annual bill was used in the DCF analysis as well as for the delta calculation for the cash and loan payment method (Figure 15).

The results for the three scenarios under different constraints in Georgetown can be seen in Table 5. The 20-year timeline cash and loan payment methods have a positive delta under each scenario. Which means that a homeowner that pays cash for a 5-10kWh system and uses between 9,000-15,000 kWh per year can expect to save a minimum of \$10,385 and up to \$19,394 over a traditional electric bill. The results for the 10-year project timeline are significantly different in that 1/3rd of the results are negative for cash payment and 4/9^{ths} are negative for the loan payment method. Many of the positive returns are low enough to suggest that the homeowner may save more by increasing energy efficiency in the home and using less electricity than by installing solar PV. For example, reducing annual usage by 3,000 kWh in Georgetown can lead to a savings of \$0.122/kWh*3,000kWh=\$366 per year or \$3,660 over 10 years. This indicates that only the small PV systems in tandem with a high annual energy use is financially beneficial and that installing solar PV for a 10-year project timeline can be costlier than improving energy efficiency and continuing to receive power from Georgetown energy.

It is important to test how local incentives affect residential solar PV without the government tax credit. The 20-year project without the tax credit is positive with a minimum savings of \$1,639 and a maximum savings of \$14,730. The savings are much lower than with the ITC but show that it is still financially beneficial for homeowners to install solar if they plan to stay in the home for 20 years. The results for the 10-year project timeline are mostly negative except for the 5kWh system for a home of 15,000 annual. The potential savings are low enough that the homeowner could reduce annual energy usage to realize the same savings. This indicates that without the ITC installing solar PV is financially costly to a homeowner that plans to sell their home after 10 years.

Based on these results, it is not financially beneficial for a homeowner to install solar PV in Georgetown unless they plan to stay in their home for longer than 10 years, regardless of if the ITC has expired or not.

Georgetown Utility Services Rates

Customer Charge	20	$/Month
Energy Charge	0.0939	$/kWh
Power Cost Adjustment	0.004	$/kWh
Transmission cost of service	0.0019	$/kWh
Sales Tax	2.00%	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Monthly Usage	937	808	749	711	830	1157	1374	1438	1407	1036	765	788	12000
Tier 1	88	76	70	67	78	109	129	135	132	97	72	74	1127
Cost before Service Charge	94	81	75	71	83	115	137	144	140	103	76	79	1198
Total Cost	$ 116	$ 103	$97	$93	$105	$138	$160	$167	$164	$126	$98	$ 101	$1,466

Average $/kWh	$ 0.122
Annual Bill	$ 1,466
Bill without customer fee	$ 1,198
Required Minimum	$ 240.00

Figure 14: Georgetown Electric Estimated Bill for 12,000 kWh Energy Use.

Georgetown Energy

Utility Rate Inputs		
Net Metering Rate	0.122	$/kWh
Utility Inflation Rate	0.0%	
O&M Costs	50	
Life of System	20	

Discounted Cash Flow	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Total PV System Cost	(22,540)																				
Incentive	-																				
Federal Tax Credit	6,762																				
Net Cost of PV System	(15,778)																				
O&M Cost		(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)
Utility Bill Cost (Check)		1,198	1,198	1,198	1,198	1,198	1,198	1,198	1,198	1,198	1,198	1,198	1,198	1,198	1,198	1,198	1,198	1,198	1,198	1,198	1,198
Solar Panel Degradation		-	0.50%	1.00%	1.50%	2.00%	2.50%	3.00%	3.50%	4.00%	4.50%	5.00%	5.50%	6.00%	6.50%	7.00%	7.50%	8.00%	8.50%	9.00%	9.50%
Utility Bill Savings		981	976	971	966	961	956	951	947	942	937	932	927	922	917	912	907	902	897	893	888
Utility Bill Minimum		(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)
Cash Flow	(15,778)	691	686	681	676	671	666	661	657	652	647	642	637	632	627	622	617	612	607	603	598
Cumulative Cash Flow	(15,778)	(15,087)	(14,401)	(13,720)	(13,044)	(12,373)	(11,707)	(11,045)	(10,389)	(9,737)	(9,090)	(8,449)	(7,812)	(7,180)	(6,553)	(5,930)	(5,313)	(4,701)	(4,093)	(3,491)	(2,893)
NPV	(6,357)																				
Simple Payback Period	20+																				
IRR	-1.90%																				

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Electric Bill		(1,466)	(1,466)	(1,466)	(1,466)	(1,466)	(1,466)	(1,466)	(1,466)	(1,466)	(1,466)	(1,466)	(1,466)	(1,466)	(1,466)	(1,466)	(1,466)	(1,466)	(1,466)	(1,466)	(1,466)
NPV of Electric Bill	(20,746)																				

Delta Electric Bill Savings	14,389

With Loan	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Loan Amount	(15,778)																				
Electric Bill Savings		981	976	971	966	961	956	951	947	942	937	932	927	922	917	912	907	902	897	893	888
Electric Bill Minimum		(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)	(240)
Interest Expense		(2,102)	(2,102)	(2,102)	(2,102)	(2,102)	(2,102)	(2,102)	(2,102)	(2,102)	(2,102)										
Annual Cash Flows		(1,361)	(1,366)	(1,371)	(1,376)	(1,381)	(1,386)	(1,391)	(1,396)	(1,400)	(1,405)	692	687	682	677	672	667	662	657	653	648
NPV	(7,535)																				

Delta of Loan	13,211

Figure 15: DCF and delta of savings of 7 kWh residential solar PV project in Georgetown, TX.

Georgetown, Texas									
20 Years with ITC									
Cash	PV System Size in kW				Loan	PV System Size in kW			
Annual kWh Use		5	7	10	Annual kWh Use		5	7	10
	9,000	$ 10,753	$ 10,385	$ 10,968		9,000	$ 10,073	$ 9,218	$ 9,111
	12,000	$ 15,073	$ 14,389	$ 13,961		12,000	$ 14,394	$ 13,211	$ 12,056
	15,000	$ 19,394	$ 18,710	$ 17,683		15,000	$ 18,715	$ 17,532	$ 15,757
10 Years with ITC									
	PV System Size in kW				Loan	PV System Size in kW			
Annual kWh Use		5	7	10	Annual kWh Use		5	7	10
	9,000	$ 1,919	$ (48)	$ (2,317)		9,000	$ 874	$ (1,636)	$ (4,697)
	12,000	$ 4,452	$ 2,296	$ (579)		12,000	$ 3,407	$ 701	$ (2,988)
	15,000	$ 6,985	$ 4,830	$ 1,596		15,000	$ 5,941	$ 3,234	$ (825)
20 Years without ITC									
Cash	PV System Size in kW				Loan	PV System Size in kW			
Annual kWh Use		5	7	10	Annual kWh Use		5	7	10
	9,000	$ 6,088	$ 3,855	$ 1,639		9,000	$ 4,735	$ 1,745	$ (1,565)
	12,000	$ 10,409	$ 7,859	$ 4,632		12,000	$ 9,056	$ 5,738	$ 1,380
	15,000	$ 14,730	$ 12,179	$ 8,354		15,000	$ 13,376	$ 10,058	$ 5,081
10 Years without ITC									
Cash	PV System Size in kW				Loan	PV System Size in kW			
Annual kWh Use		5	7	10	Annual kWh Use		5	7	10
	9,000	$ (2,746)	$ (6,578)	$(11,645)		9,000	$ (4,464)	$ (9,109)	$(15,373)
	12,000	$ (212)	$ (4,234)	$ (9,908)		12,000	$ (1,931)	$ (6,772)	$(13,664)
	15,000	$ 2,321	$ (1,701)	$ (7,733)		15,000	$ 603	$ (4,239)	$(11,501)

Table 5: Scenario results under 4 different constraints indicating the cost savings (losses) of installing residential solar PV over paying traditional energy bill in Georgetown, TX.

7.3 CPS ENERGY

The monthly and annual energy bill for a home that uses 12,000 kWh per year in the CPS Energy service area is depicted in Figure 16. The calculated average is \$0.1076/kWh which is about the same as the San Antonio service area average of \$0.1073/kWh (Table 3). The annual bill was used in the DCF analysis as well as for the delta calculation for the cash and loan payment method (Figure 17).

The results for the three scenarios under different constraints in San Antonio can be seen in Table 6. The 20-year timeline cash and loan payment methods have a positive delta under each scenario. Which means that a homeowner that pays cash for a 5-10kWh system and uses between 9,000-15,000 kWh per year can expect to save a minimum of \$12,517 and up to \$30,153 over a traditional electric bill. While not as high, the results for a 10-year project timeline is mostly positive, the exception being the 10kWh system with an annual usage of 9,000 kWh, indicating that installing solar is still financially beneficial over a shorter time horizon. The San Antonio homeowner could increase energy efficiency and reduce energy usage by 3,000 kWh annually and save \$0.1076/kWh*3,000kWh=\$323 per year, or \$3,228 over 10 years. This potential savings through energy efficiency indicate that some of the scenarios under loan payment are less favorable and it is important for a homeowner to evaluate all possible means of reducing energy usage before installing residential solar PV. Regardless of energy reduction, the 10-year time horizon is mostly positive leading to cost savings for the homeowner.

The results without the government investment tax credit show a similar outcome to that of Austin, TX. The 20-year project without the tax credit is positive with a minimum savings of \$3,188 and a maximum savings of \$22,358. The savings are much lower than with the ITC but show that it is still financially beneficial for homeowners to install solar if they plan to stay in the home for 20 years. The results for the 10-year project timeline are different than the previous scenarios with many of the outcomes being negative or extremely low, except for the 5kWh system for a home of 12,000 and 15,000 annual kWh usage and the 7kWh system for an annual usage of 15,000 kWh. Much of the meager savings could be realized by reduction of annual energy use. This indicates that without the ITC a large system size is financially costly to a homeowner that plans to sell their home after 10 years.

An additional analysis for CPS Energy was that of the cost savings to a homeowner from participating in the SolarHostSA program, the savings over a traditional energy bill for a home that uses 9,000 to 15,000 kWh per year and a time horizon of 10 and 20 years is portrayed in Table 7. The homeowner will realize a $0.03/kWh savings regardless of the system size for up to 20 years. While the savings seem modest compared to some of the solar installation scenarios, the savings are not affected by an expiration of the ITC and are guaranteed.

CPS Energy Tier

Service Availability Charge	8.75 $/Month
Jun-Sept 0-600 kWh	0.0691 $/kWh
Jun-Sept >600 kWh Peak Capacity Charge	0.0198 $/kWh
Oct-May 0-600 kWh	0.0691 $/kWh
Oct-May >600 kWh	0.0592 $/kWh
Fuel Adjustment	0.01525 $/kWh
Regulatory Adjustment	0.01007 $/kWh
Sales Tax	1%

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Monthly	937	808	749	711	830	1157	1374	1438	1407	1036	765	788	12000
Tier 1	41	41	41	41	41	41	41	41	41	41	41	41	498
Tier 2	20	12	9	7	14	49	69	74	72	26	10	11	372
Cost before Service Charge	85	74	69	66	76	120	145	152	149	93	71	72	1173
Total Cost	$ 95	$ 84	$79	$75	$86	$130	$155	$163	$159	$ 103	$80	$82	$1,291

Average $/kWh	$ 0.108
Annual Bill	$ 1,291
Bill without customer fee	$ 1,173
Required Minimum	105

Figure 16. CPS Energy Estimated Bill for 12,000 kWh Energy Use.

CPS Energy

Inputs		
PV Application Fee	100	
Commisioning Charge	300	
Net Metering	-	$/kWh
Inflation Rate	2.0%	
Residential PV Rebate	0.7	$/Watt
Rebate Max Capacity	-	kW
Rebate Max	25,000	$/System
O&M Costs	50	
Life of System	20	

Discounted Cash Flow	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Total PV System Cost	(22,540)																				
Rebate	4,900																				
Federal Tax Credit	6,762																				
Net Cost of PV System	(11,278)																				
O&M Cost		(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)
Electric Bill without Solar (Check)		1,173	1,197	1,220	1,245	1,270	1,295	1,321	1,347	1,374	1,402	1,430	1,459	1,488	1,518	1,548	1,579	1,610	1,643	1,675	1,709
Solar Panel Degradation		-	0.50%	1.00%	1.50%	2.00%	2.50%	3.00%	3.50%	4.00%	4.50%	5.00%	5.50%	6.00%	6.50%	7.00%	7.50%	8.00%	8.50%	9.00%	9.50%
Electric Bill Savings		961	975	990	1,004	1,019	1,034	1,050	1,065	1,081	1,097	1,113	1,129	1,145	1,162	1,179	1,196	1,213	1,231	1,249	1,267
Electric Bill Minimum		(105)	(107)	(109)	(111)	(114)	(116)	(118)	(121)	(123)	(125)	(128)	(131)	(133)	(136)	(139)	(141)	(144)	(147)	(150)	(153)
Cash Flow	(11,278)	806	818	830	843	855	868	881	894	908	921	935	948	962	976	990	1,005	1,019	1,034	1,049	1,064
Cumulative Cash Flow	(11,278)	(10,472)	(9,654)	(8,824)	(7,981)	(7,126)	(6,257)	(5,376)	(4,482)	(3,574)	(2,653)	(1,718)	(770)	192	1,168	2,159	3,163	4,183	5,217	6,265	7,329
NPV	1,607																				
Simple Payback Period	13.80																				
IRR	5.05%																				

Discounted Cash Flow	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Electric Bill		(1,291)	(1,317)	(1,343)	(1,370)	(1,397)	(1,425)	(1,454)	(1,483)	(1,512)	(1,543)	(1,574)	(1,605)	(1,637)	(1,670)	(1,703)	(1,737)	(1,772)	(1,808)	(1,844)	(1,881)
NPV of Electric Bill	(21,686)																				

Delta Utility Bill Savings	23,293

With Loan	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Loan Amount	(11,278)																				
Electric Bill Savings		961	975	990	1,004	1,019	1,034	1,050	1,065	1,081	1,097	1,113	1,129	1,145	1,162	1,179	1,196	1,213	1,231	1,249	1,267
Electric Bill Minimum		(105)	(107)	(109)	(111)	(114)	(116)	(118)	(121)	(123)	(125)	(128)	(131)	(133)	(136)	(139)	(141)	(144)	(147)	(150)	(153)
Interest Expense		(1,503)	(1,503)	(1,503)	(1,503)	(1,503)	(1,503)	(1,503)	(1,503)	(1,503)	(1,503)										
Annual Cash Flows		(647)	(635)	(622)	(610)	(597)	(584)	(571)	(558)	(545)	(531)	985	998	1,012	1,026	1,040	1,055	1,069	1,084	1,099	1,114
	4,582																				
NPV	1,186																				

Delta with Loan	22,871

Figure 17: DCF and delta of savings of 7 kWh residential solar PV project in San Antonio, TX.

San Antonio, Texas								
20 Years with ITC								
Cash	PV System Size in kW			Loan	PV System Size in kW			
Annual kWh Use		5	7	10	Annual kWh Use		5	7	10
	9,000	$ 17,026	$ 17,019	$ 12,517		9,000	$ 16,886	$ 16,552	$ 11,399
	12,000	$ 22,042	$ 23,293	$ 22,081		12,000	$ 21,902	$ 22,871	$ 21,126
	15,000	$ 27,023	$ 28,275	$ 30,153		15,000	$ 26,883	$ 27,853	$ 29,308

10 Years with ITC									
Cash		PV System Size in kW			Loan		PV System Size in kW		
Annual kWh Use		5	7	10	Annual kWh Use		5	7	10
	9,000	$ 5,611	$ 4,258	$ (244)		9,000	$ 5,047	$ 3,319	$ (1,833)
	12,000	$ 8,307	$ 7,648	$ 4,957		12,000	$ 7,744	$ 6,734	$ 3,457
	15,000	$ 10,985	$ 10,326	$ 9,337		15,000	$ 10,422	$ 9,412	$ 7,898

20 Years without ITC									
Cash		PV System Size in kW			Loan		PV System Size in kW		
Annual kWh Use		5	7	10	Annual kWh Use		5	7	10
	9,000	$ 12,362	$ 10,489	$ 3,188		9,000	$ 11,548	$ 9,078	$ 723
	12,000	$ 17,377	$ 16,763	$ 12,752		12,000	$ 16,564	$ 15,398	$ 10,449
	15,000	$ 22,358	$ 21,745	$ 20,824		15,000	$ 21,545	$ 20,380	$ 18,632

10 Years without ITC									
Cash		PV System Size in kW			Loan		PV System Size in kW		
Annual kWh Use		5	7	10	Annual kWh Use		5	7	10
	9,000	$ 946	$ (2,272)	$ (9,573)		9,000	$ (291)	$ (4,154)	$(12,509)
	12,000	$ 3,643	$ 1,118	$ (4,372)		12,000	$ 2,406	$ (739)	$ (7,219)
	15,000	$ 6,321	$ 3,796	$ 9		15,000	$ 5,084	$ 1,939	$ (2,778)

Table 6: Scenario results under 4 different constraints indicating the cost savings (losses) of installing residential solar PV over paying traditional energy bill in San Antonio, TX.

NPV with SolarHostSA		Time Horizon (years)	
Annual kWh Use		10	20
	9,000	$ 2,240	$ 3,820
	12,000	$ 2,986	$ 5,093
	15,000	$ 3,733	$ 6,367

Table 7: Scenario results for savings from participating in CPS SolarHostSA program.

7.4 Comparative Analysis

The results indicate an overarching pattern present in the three cities and that is that a long-time horizon leads to positive net savings over a traditional electric bill, the ITC significantly improves savings, and the project is likely to be uneconomical without the ITC over a short project timeline. Another important takeaway is that a rebate or capital reduction incentive is more valuable than net-metering or a value of solar tariff. The cost savings realized by the San Antonio households are higher than Austin and significantly higher than Georgetown despite both cities having a generous net-metering or value of solar tariff and San Antonio's lack of net-metering.

Installing solar PV is capital intensive and without a government tax credit, a project needs a lengthy time horizon to recoup the costs. The findings also suggest that a potential buyer should consider installing solar sooner rather than later to take advantage of the ITC. Since the presence of solar panels does not generally impact the sale price of a home, the system must be considered a sunk cost and fully paid off if a home is to be sold. If a homeowner intends to adopt residential solar PV for the potential cost savings, they should consider a realistic time horizon and install prior to the expiration of the ITC. If a homeowner intends to move in 10 years or less and the ITC has expired, they are financially better off foregoing installing residential solar and continuing to receive energy from the local utility.

Chapter 8: Equal, Equitable, or Optimal

8.1 Definition

Equal, equitable, and optimal can aid in categorizing the motives and intentions of the cities studied and additional cities. Equal is defined as having the same amount as another, acting in an impartial manner, and "capable of meeting the requirements of a situation or a task."[71] In terms of policies that influence the adoption of residential solar PV, equal means that the policies are applied to all citizens in an impartial manner and that what is offered in terms of incentives and rebates meets the requirements of a city's goal towards solar installation. Equitable represents a sense of fairness and can define a category of city policies that enables fair access to residential solar resources regardless of socioeconomic class. The optimal category is concerned with finding the most desirable and effective financial and environmental outcome for the city regardless of if it promotes the adoption of residential solar PV.

8.2 Equal

The policies and actions of Austin are reflective of an equal system. The city offers generous system rebates and value of solar credits for those that can afford to install solar. The value of solar credit is designed in a way to treat a homeowner with solar PV as an energy producer that is paid $0.097 per kWh while still paying for all energy consumed based on the tiered rate system. Austin Energy chose to eliminate net metering and treat all energy consumers equally regardless of if a home has solar panels, further proof that Austin should be categorized as an equal system. Those that cannot install solar, due to poor solar insolation or living in a rented space, can pay an additional of $10-$18 on their energy bill to participate in Austin community solar.[72] The city offers the same solar programs and incentives to all citizens and therefore the city acts in an equal way. The programs do not account for socioeconomic levels and can best be used by citizens who are able to pay more per month or afford the high initial cost of installing solar.

8.3 Equitable

San Antonio has created a more equitable system that enables fair access to residential solar. While Austin Energy provides a rebate that maxes out at $4,000, CPS Energy provides a larger rebate and one that maxes out at $25,000. The rebate is higher for residents that choose to use locally manufactured panels and inverters, implying that the city is attempting to promote fairness among locally and internationally produced systems. This high rebate in partnership with the SolarHostSA program provides a lucrative incentive that can benefit the lowest income household to the household that can install a large and expensive system. CPS Energy includes residential solar into the renewable energy generation capacity goal and so incentivizing solar aligns with utility objectives. It is appropriate to categorize San Antonio as using an equitable system when it comes to solar.

8.4 Optimal

Georgetown utility services focused on securing long term, fixed rate, contracts to optimize energy savings. It is implied that by not offering solar rebates the city believes that there is a better use of capital. The net-metering at retail rate seems like an incentive to the consumer but it acts as a fixed payment for the city to purchase excess generation from homeowners. Georgetown Energy is researching and investing in a virtual powerplant system and intends to compensate, through lease payments or royalties, homeowners in ideal locations that install solar.[73] The intention is to stabilize prices and lower overall costs by eliminating extremely costly peak demand prices.[74] It is apparent that Georgetown's energy policies and goals should be categorized as Optimal.

Chapter 9: Conclusion

It is evident, that in the case of Austin, San Antonio, and Georgetown, the approach taken towards implementing solar energy can have a significant financial impact on residential utility customers. Cities that more heavily subsidize a solar PV system save customers far more than cities that do not subsidize. However, the most meaningful incentive is the federal investment tax credit and the presence or absence of it can dramatically affect the net savings to a customer over a short-term project horizon. Programs like SolarHostSA provide guaranteed savings for customers but at a lower rate than some of the traditional solar PV scenarios. Federal and local incentive structures reduce the capital cost of installing residential solar PV, but consumers need to fully understand their energy usage, needs, and timeline to properly justifying partaking in the capital-intensive project of installing solar.

Aside from the financial impact on residents, the solar policies and programs that cities put forth, speak to the overarching policy model present in each city. The three cities, Austin, San Antonio, and Georgetown, fall into the categories of equal, equitable, or optimal, respectively. Austin, categorized as equal, promotes a model where all participants in solar are treated the same, regardless of socioeconomic standing. This is most evident by both the tiered rebate system that returns \$0.40 per kW up to \$4,000 regardless of system origin or household income, and especially the value of solar tariff that treats all solar panel owners as traditional energy users while crediting homes for the energy produced from their solar PV systems.

San Antonio, categorized as equitable, emphasizes a model that treats residents and participants in residential solar PV in a fair manner. This is evident in the rebate system that incentivizes all participants in residential solar PV but rebates more to those that choose locally manufactured panels and inverters over internationally manufactured systems. The SolarHostSa program is especially equitable in that it provides all homeowners, regardless of socioeconomic level, the ability to take advantage of and benefit from residential solar PV. Those that can afford it, can save even more by installing residential solar PV.

Georgetown, categorized as optimal, puts very little emphasis on residential solar PV and promotes a model that is intended to reduce and stabilize costs for the city. Georgetown has already agreed to purchase 100% renewable energy through its power purchase agreements and will not benefit in the same manner as Austin and San Antonio would by promoting residential solar PV. The city has optimized cost savings over the next 25 years while reducing emissions. Instead, Georgetown has shifted its focus to optimizing grid stability as can be seen by its research and implementation of virtual powerplants through compensating residential solar PV in advantageous solar resource locations.

Understanding these models and categorizations can provide a blueprint for other cities that wish to implement programs to increase renewable solar energy. A city can decide whether it wants to be equal, equitable, or optimal and can choose programs and policies that best align with the intended model. Other cities can also use the financial model to analyze the value of residential solar PV to their citizens and tailor the model to match their ideal incentive structure.

An important result was the potential costs of installing residential solar in the absence of the investment tax credit over the short term, it is yet to be seen how cities will alter incentive structures once the credit expires and how it will impact adoption rates. Further research into the effects of the expiration of the ITC on cities and residents should be done.

References

[1] "Monthly Energy Review." *Monthly Energy Review*, 21 Nov. 2017, www.eia.gov/mer.
[2] "Public Utility Regulatory Policies Act of 1978 (PURPA)". (16 U.S.C. ch. 46 § 2601 et seq.)
[3] "Energy Policy Act of 1992". (42 U.S.C § 13201 note.)
[4] "History of ERCOT." *Electric Reliability Council of Texas (ERCOT)*, ERCOT, www.ercot.com/about/profile/history.
[5] "Energy Deregulation Texas." *Energy Deregulation Texas RSS*, www.energyderegulationtexas.com/energy-deregulation-texas/.
[6] "Frequently Asked Questions." *PUCTX*, Public Utility Commission of Texas, www.puc.texas.gov/consumer/facts/faq/Muni.aspx.
[7] Gilroy, Nicholas. "Direct Normal Solar Resource of Texas." *Solar Maps | Geospatial Data Science | NREL*, 04 Apr. 2017, www.nrel.gov/gis/solar.html.
[8] "Equations and Variables in ATB." *National Renewable Energy Laboratory*, NREL, 2017, atb.nrel.gov/electricity/2017/equations-variables.html.
[9] "LCOE with Environmental Costs*." *Energy Institute*, The University of Texas at Austin, 2017, calculators.energy.utexas.edu/lcoe_detailed/.
[10] Speer, Bethany. *Residential Solar Photovoltaics: Comparison of Financing Benefits, Innovations, and Options*. NREL, 2012, *Residential Solar Photovoltaics: Comparison of Financing Benefits, Innovations, and Options*.
[11] Desai, Niraj. "Residential PV Solar Industry from Engineer at Solar Installation Company." 9 Feb. 2018.
[12] "Residential Average Monthly KWh and Bills | Open Data | City of Austin Texas." *Data.AustinTexas.gov*, City of Austin, 2018, data.austintexas.gov/Utilities-and-City-Services/Residential-Average-Monthly-kWh-and-Bills/d9pb-3vh7/data.
[13] "US Inflation Rate." *US Inflation*, 13 Mar. 2018, usinflation.org/us-inflation-rate/.
[14] Foster, Chris. "Georgetown Renewable Energy and Residential Solar PV." 25 Oct. 2017.
[15] "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." *Electricity Data Browser*, EIA, 2018, www.eia.gov/electricity/data/browser/#/topic/7?agg=0,1&geo=0000000002&endsec=vg&linechart=~ELEC.PRICE.TX-RES.A&columnchart=ELEC.PRICE.TX-ALL.A&map=ELEC.PRICE.TX-ALL.A&freq=A&start=2007&end=2017&chartindexed=1&ctype=linechart<ype=pin&rtype=s&pin=&rse=0&maptype=0.
[16] Tarbi, Luke. "2018 Cost of Solar Panels in Austin, Texas | EnergySage." *EnergySage Solar News Feed*, EnergySage, 29 Sept. 2017, news.energysage.com/how-much-does-a-solar-energy-system-cost-in-austin-texas/.
[17] "Solar Investment Tax Credit (ITC)." *SEIA*, Solar Energy Industries Association, www.seia.org/initiatives/solar-investment-tax-credit-itc.

[18] Sokolic, Kathy. "Impact of Solar Installation on House Sales." *Impact of Solar Installation on House Sales*, 1 Mar. 2018.
[19] Richardson, Luke. "How Long Will My Solar Panels Last? | EnergySage." *EnergySage Solar News Feed*, EnergySage, 4 May 2017, news.energysage.com/how-long-do-solar-panels-last/.
[20] Starrs, Tom, and Howard Wenger. "How Much Does a PV System Cost?" *A Consumer's Guide: Get Your Power from the Sun*, www.nrel.gov/docs/fy04osti/35297.pdf.
[21] Zientara, Ben. "How to Calculate the Amount of Kilowatt Hours (KWh) Your Solar Panel System Will Produce." *Solar Power Rocks*, 2017, solarpowerrocks.com/buying-solar/how-to-calculate-the-amount-of-kilowatt-hours-kwh-your-solar-panel-system-will-produce/.
[22] Starrs, Tom, and Howard Wenger. "How Much Does a PV System Cost?" *A Consumer's Guide: Get Your Power from the Sun*, www.nrel.gov/docs/fy04osti/35297.pdf.
[23] "Moody's Seasoned Aaa Corporate Bond Yield." *FRED*, Federal Reserve Bank of St. Louis, 1 Jan. 2018, fred.stlouisfed.org/series/AAA.
[24] "Local Data on Solar Panels in Texas." *EnergySage*, US Department of Energy, 24 Mar. 2018, www.energysage.com/solar-panels/tx/.
[25]"Energy Use & Sales." *Austin Energy*, City of Austin, austinenergy.com/ae/about/reports-and-data-library/data-library/energy-use-and-sales.
[26] "Renewable Generation Requirement". (Tex. Utilities Code Ann. § 39.904.)
[27] Durkay, Jocelyn. "State Renewable Portfolio Standards and Goals." *NCSL*, National Conference of State, 1 Aug. 2017, www.ncsl.org/research/energy/renewable-portfolio-standards.aspx.
[28] "Texas Renewable Electricity Mandate Status." *IER*, Institute for Energy Research, instituteforenergyresearch.org/renewable-mandates/texas-renewable-electricity-mandate-status/.
[29] Public Utility Commission of Texas, *Rules §25.173. Goal for Renewable Energy*, http://www.puc.state.tx.us/rules/subrules/electric/25.173/25.173.pdf.
[30] "Solar Investment Tax Credit (ITC)." *SEIA*, Solar Energy Industries Association, 2017, seia.org/initiatives/solar-investment-tax-credit-itc.
[31] Robinson, Ryan. "Demographics." *Home*, City of Austin, 1 Apr. 2017, www.austintexas.gov/demographics.
[32] "Company Profile." *Austin Energy*, City of Austin, www.austinenergy.com/.
[33] "Austin Energy Service Area." *Austin Energy Company Profile*, City of Austin, 2018, austinenergy.com/ae/about/company-profile/electric-system/service-area-map/.
[34] "Renewable Power Generation." *Austin Energy Environment*, City of Austin, 2018, austinenergy.com/ae/about/environment/renewable-power-generation.
[35] Austin Energy. Annual Performance Report Year Ended September 2015.
[36] "Austin Energy At-A-Glance." *Austin Energy*, City of Austin, austinenergy.com/.
[37] "Renewable Power Generation." *Austin Energy*, City of Austin, austinenergy.com/.

[38] "Residential Electric Rates & Line Items." *Austin Energy Rates*, City of Austin, 2018, austinenergy.com/ae/residential/rates/residential-electric-rates-and-line-items.
[39] "Rates." *Austin Energy Rates*, City of Austin, 27 Dec. 2016, austinenergy.com/wcm/connect/fc39b1c5-a83f-4d08-bada-a89c4bd11c39/RatesFees1216P5.pdf?MOD=AJPERES&CVID=lBc2m9R&CVID=lBc2m9R&CVID=lBc2m9R.
[40] "Solar Solutions." *Austin Energy Solar Solutions*, City of Austin, 2018, austinenergy.com/ae/green-power/solar-solutions/solar-solutions.
[41] "Solar Photovoltaic (PV) Rebates & Incentives." *Austin Energy Solar Solutions*, City of Austin, 2018, austinenergy.com/ae/green-power/solar-solutions/for-your-home/solar-photovoltaic-rebates-incentives.
[42] "Current Solar Incentive Levels." *Austin Energy Solar Solutions*, City of Austin, 2018, austinenergy.com/ae/green-power/solar-solutions/participating-solar-contractors/current-solar-incentive-levels.
[43] "Value-Of-Solar Rider." *Austin Energy*, City of Austin, 1 Nov. 2017, austinenergy.com/wcm/connect/c6c8ad20-ee8f-4d89-be36-2d6f7433edbd/value-solar-rider.pdf?MOD=AJPERES&CVID=m2Tl5QA&CVID=m2Tl5QA&CVID=m2Tl5QA&CVID=m2Tl5QA&CVID=lZU-uHq&CVID=lBc2pcr&CVID=lBc2pcr&CVID=lBc2pcr&CVID=lBc2pcr&CVID=lBc2pcr&CVID=lBc2pcr&CVID=lBc2pcr&CVID=lBc2pcr&CVID=lBc2pcr&CVID=lBc2pcr&CVID=lBc2pcr&CVID=lBc2pcr&CVID=lBc2pcr&CVID=lBc2pcr&CVID=lBc2pcr&CVID=lBc2pcr&CVID=lBc2pcr.
[44] "Community Solar." *Austin Energy Solar Solutions*, City of Austin, 2018, austinenergy.com/ae/green-power/solar-solutions/for-your-home/community-solar/community-solar.
[45] "Austin Energy Sales - Revenue by Customer Class." *Data.AustinTexas.gov*, City of Austin, 2016, data.austintexas.gov/Utilities-and-City-Services/Austin-Energy-Sales-Revenue-by-Customer-Class/vgrz-3ke5/data.
[46] "LCOE with Environmental Costs*." *Energy Institute | The University of Texas at Austin*, Energy Institute, 2 Nov. 2017, calculators.energy.utexas.edu/lcoe_detailed/.
[47] "Simple Levelized Cost of Energy (LCOE) Calculator Documentation." *Simple Levelized Cost of Energy (LCOE) Calculator Documentation | Energy Analysis*, NREL, www.nrel.gov/analysis/tech-lcoe-documentation.html.
[48] "People Overview." *Georgetown, Texas People*, Sperling's Best Places, 2018, www.bestplaces.net/people/city/texas/georgetown.
[49]"Georgetown Utility Info." *ArcGIS Web Application*, City of Georgetown Texas, georgetowntx.maps.arcgis.com/apps/webappviewer/index.html?id=43e000b1e2f54464acf9ccb2a7dbe50b.
[50] Foster, Chris. "Georgetown Renewable Energy and Residential Solar PV." 25 Oct. 2017.
[51] "FAQ Solar Process." *Georgetown Utility Systems*, City of Georgetown Texas, 14 Apr. 2016, gus.georgetown.org/electric/faq-solar-process/.

[52] "FY2017 Annual Budget." *Georgetown Texas Electric Fund*, 2017, finance.georgetown.org/files/2016/06/05-Electric-Fund-2017.pdf.
[53] "Rates." *Georgetown Utility Systems*, City of Georgetown Texas, 1 June 2017, gus.georgetown.org/customercare/rates/.
[54] "QuickFacts San Antonio City, Texas." *The United States Census Bureau*, US Department of Commerce, 1 July 2017, www.census.gov/quickfacts/fact/table/sanantoniocitytexas/PST045216sus.gov/quickfacts/fact/table/sanantoniocitytexas/PST045216.
[55] "Building History with San Antonio." *CPS Energy*, City of San Antonio, www.cpsenergy.com/en/about-us/who-we-are.html.
[56]"CPS Energy Service Boundary." *CPS Energy*, www.cpsenergy.com/content/dam/corporate/en/Documents/CPS_Energy_Service_Boundaries.pdf.
[57] "Nuclear Energy." *CPS Energy*, City of San Antonio, 2018, cpsenergy.com/en/about-us/programs-services/energy-generation/nuclear-energy.html.
[58] "Coal." *CPS Energy*, City of San Antonio, 2018, cpsenergy.com/en/about-us/programs-services/energy-generation/coal.html.
[59] "Landfill Gas." *CPS Energy*, City of San Antonio, 2017, cpsenergy.com/en/about-us/programs-services/energy-generation/landfill-gas.html.
[60]"San Antonio City Public Service (CPS Energy) - Renewable Portfolio Goal." *Energy.Gov*, Department of Energy, www.energy.gov/savings/san-antonio-city-public-service-cps-energy-renewable-portfolio-goal.
[61] Druzin, Rye. "CPS Energy Plans to Generate Half Its Power from Clean Energy Sources by 2040." *San Antonio Express-News*, Express-News, 7 Mar. 2018, www.mysanantonio.com/business/eagle-ford-energy/article/CPS-Energy-plans-to-generate-half-its-power-from-12733088.php.
[62]"Corporate Fact Sheet." *CPS Energy*, cpsenergy.com/content/dam/corporate/en/Documents/Trustees/CPS%20Energy%20Corporate%20Fact%20Sheet%20-%2002142018.pdf.
[63] "How to Read Your Bill." *CPS Energy*, www.cpsenergy.com/content/dam/corporate/en/Documents/Your_Bill.pdf.
[64] "CPS Energy - Solar PV Rebate Program." *Energy.Gov*, Department of Energy, energy.gov/savings/cps-energy-solar-pv-rebate-program.
[65] "Solar Rebate Incentive Tiers." *CPS Energy*, City of San Antonio, www.cpsenergy.com/en/my-home/savenow/rebates-rebate/solar-photovoltaic-rebate/comm-solar-rebate-incentive-tiers.html.
[66] "CPS Energy-Simply Solar." *CPS Energy*, City of San Antonio, www.cpsenergy.com/en/my-home/savenow/simply-solar.html.
[67]"Roofless Solar." *CPS Energy*, City of San Antonio, www.cpsenergy.com/en/my-home/savenow/simply-solar/community-roofless-solar.html.
[68] "Frequently Asked Questions." *SolarHost San Antonio*, City of San Antonio, www.solarhostsa.com/#faq.

[69] CPS Energy. 2016/2017 Annual Report.
[70] "Electric Sales, Revenue, and Average Price 2016 ." *U.S. Energy Information Administration - EIA - Independent Statistics and Analysis*, US Energy Information Administration, 6 Nov. 2017, www.eia.gov/electricity/sales_revenue_price.
[71] "Equal." *Merriam-Webster*, Merriam-Webster, www.merriam-webster.com/dictionary/equal.
[72] "Community Solar." *Austin Energy*, City of Austin, austinenergy.com/ae/green-power/solar-solutions/for-your-home/community-solar/community-solar.
[73] Davis, Chris. "Central Texas City Wants to Pay People to Install Solar Panels." *KXAN*, 30 Mar. 2018, www.kxan.com/news/local/williamson-county/central-texas-city-wants-to-pay-people-to-install-solar-panels/1089026249.
[74] Foster, Chris. "Georgetown Renewable Energy and Residential Solar PV." 25 Oct. 2017.